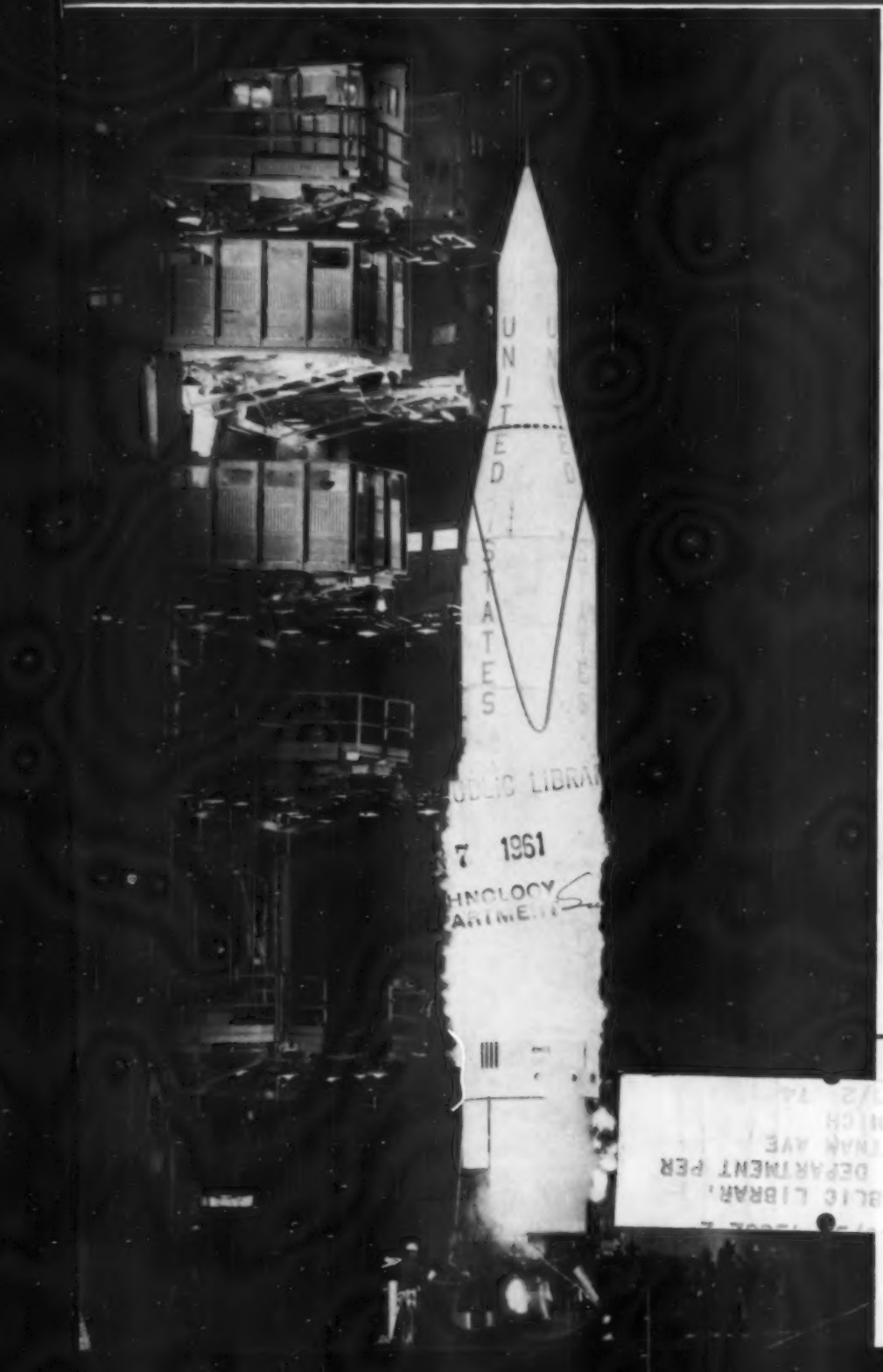
APRIL 3, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY

V.8 #14



JFK Asks Big Polaris Build-up— Shuns DOD Space Plans

- Funds to Aid NASA Boosters
- Breakthrough For Beryllium
- F-1 Engines Tests to Start

S-15 Near First Launching

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Monsanto

Space-Age Project "NEW MOLECULES"

CHEMICAL EXPEDITIONS BY

Monsanto Research Corporation . . . mapping pathways to unique molecules that solve difficult military and industrial problems

Engineers in the rapidly expanding aerodynamic, electronic and mechanical sciences are hampered by having to accommodate their needs to conventional compounds that are "on hand." Monsanto recognized this problem as vital to defense and to industry, and established the Monsanto Research Corporation, a wholly owned subsidiary with research facilities largely devoted to study of scientific problems facing our government. The Monsanto Research Corporation is making significant advances toward solving a number of today's critical material needs.

The Monsanto Research Corporation conducts research and development programs to produce special new materials to fit specific requirements. This laboratory focuses the scientific resources of a major chemical company on creating special molecules. Here, basic science and applied technology in organic, inorganic, polymer and petroleum chemistry are integrated in the creative expedition.

Available to the government and prime contractors for contract research, the Monsanto Research Corporation provides the maximum probability of ultimate success in developing chemical materials for space-age technology because the "know-how" and research effort are concentrated in one well-rounded organization. It is currently at work in a number of vital areas of technology:

SOLID PROPELLANTS . . .

for the Bureau of Naval Weapons, exploring complete new types of solid propellants. As a creator, developer and producer of commercial chemicals, Monsanto's studies are directed at altogether new chemical systems of energy release for solid core rockets.

HULL-VIBRATION DAMPING . . .

for the Navy, Bureau of Ships, developing plastic coatings to damp vibration of metal parts. Study has developed a mathematical formula that relates actual engineering damping to fundamental constants of the polymers. Developed to date: a series of compounds that promise to be twice as effective as any previously known.

HIGH-HEAT-STABLE FLUORINE COMPOUNDS . . .

showing the most promise for use as high-temperature lubricants and fluids for the Air Force. By critical screening, Monsanto research has determined that perfluorobenzene appears to be a highly heat-stable building block. By screening various types of compounds, this order of heat stability was disclosed: certain compounds with fluorine and carbon only—stability greater than 1000°F.; special aromatics—up to 1000°F.; nitrogen heterocyclics—up to 950°F.; silicon compounds—to 900°F.; phosphorus compounds—to 850°F. Several major fields of fluorine chemistry have been "blocked out" and the research begun for heat-stable fluids and lubricants.

CONTROLLED-PERMEABILITY FILMS . . .

research for the Office of Saline Water on plastic sheeting that can rapidly pass water but retain the ions of dissolved salts. These films would have a controlled permeability based upon their molecular structure—in effect, hold promise for separating a variety of salts from solution and specifically for purifying sea water.

INORGANIC POLYMERS . . .

for the Air Force—investigating the bond strength of linkages between various combinations of nonmetals to find "plastics" composed of molecules with phosphorus-to-carbon-to-sulfur bonds; macromolecules with ionic bonding; nitrilic chlorides; cyano-fluorocarbons; and several types of metal-phosphorus-carbon linear polymers.

HEAT-RESISTANT ADHESIVES . . .

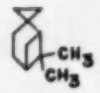
for the Air Force—polymers to develop high bond strengths between dissimilar materials at elevated temperatures. One series of polymers may yield metal-to-metal bonding that holds firm at 500-700°F., might be used to glue ovens together —and in many plants to eliminate welding.

HIGH-TEMPERATURE LAMINATING RESINS . . .

for the Air Force—studies proceeding with a new series of resins that apply as easily as water to blotting paper, that catalytically cure at room temperature, and withstand exposure to temperatures of 500-700°F.

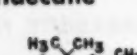
HYDROCARBON FUEL SYNTHESIS AND EVALUATION . . .

screening compounds for improved jet fuels. Under Air Force contract, some exotic and highly interesting fuel candidates have been prepared, including compounds with spirane linking, steric crowding, and cyclopropyl groupings. Some unusual candidate compounds never before prepared include:

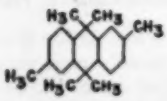


5,5-dimethyl-4,6-methanospiro [2.5] octane

1-isobutyltricyclo [5.2.1.0^{2,6}] decane



dispiro [5.0.5.1] tridecane



2,2,5,9,9,12-hexamethyltricyclo-[8.4.0.0^{3,8}] tetradecane

HIGH-TEMPERATURE LUBRICANT ADDITIVES . . .

for the Air Force—to provide extreme-pressure properties, pour-point modification, viscosity-index improvement, and oxidation resistance to synthetic lubricants that must operate in the temperature range of 600-800°F.

This simple apparatus was developed by Monsanto in collaboration with the WADD Materials Laboratory. In this simple refined form, it is essentially a modified Bodenstein gauge and is used to measure accurately the thermal stability of as little as 0.2 gram of liquid or solid up to above 1000° F.

In addition to the foregoing, Monsanto scientists are studying the chemistry of semiconductors, micro-metallic oxides, electroluminescents, fuel cells, molecular separation of helium, intra-metal thermocouples, radiation-resistant coolants and heat-transfer fluids.

SPECIAL MATERIALS FOR SPACE-AGE ENGINEERING...a chemical capability of Monsanto

Supersonic vehicles, guidance systems, satellites, data-transmission systems, solar batteries, early-warning networks—their rapid evolution has overrun the performance of existing materials. New materials—of many kinds—are urgently needed. These new materials start from new molecules, and Monsanto research chemists, whose professional *raison d'être* is creating new molecules, can help other scientists whose major interests are the finished items—not the stuff of which they are made or the numerous and complex "goops" essential for space-age hardware operation.

Monsanto's knowledge of synthesis of materials is a valuable adjunct available to specialists in many fields of advanced engineering. When your project requires a material with special properties, you are invited to discuss your needs with Monsanto. Write or call: MONSANTO CHEMICAL COMPANY, Department MR-3, C Building, St. Louis 66, Missouri.

For further details on Monsanto's capabilities in the field of special materials development, request a copy of bulletin RE-1: PEOPLE AND PROJECTS.

Monsanto

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 8, Number 14 April 3, 1961

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THE COVER

Night fueling of Juno II test vehicle with S-15 atop upper stages prior to a recent static test. The gamma ray satellite will be launched soon. See story on p. 19.

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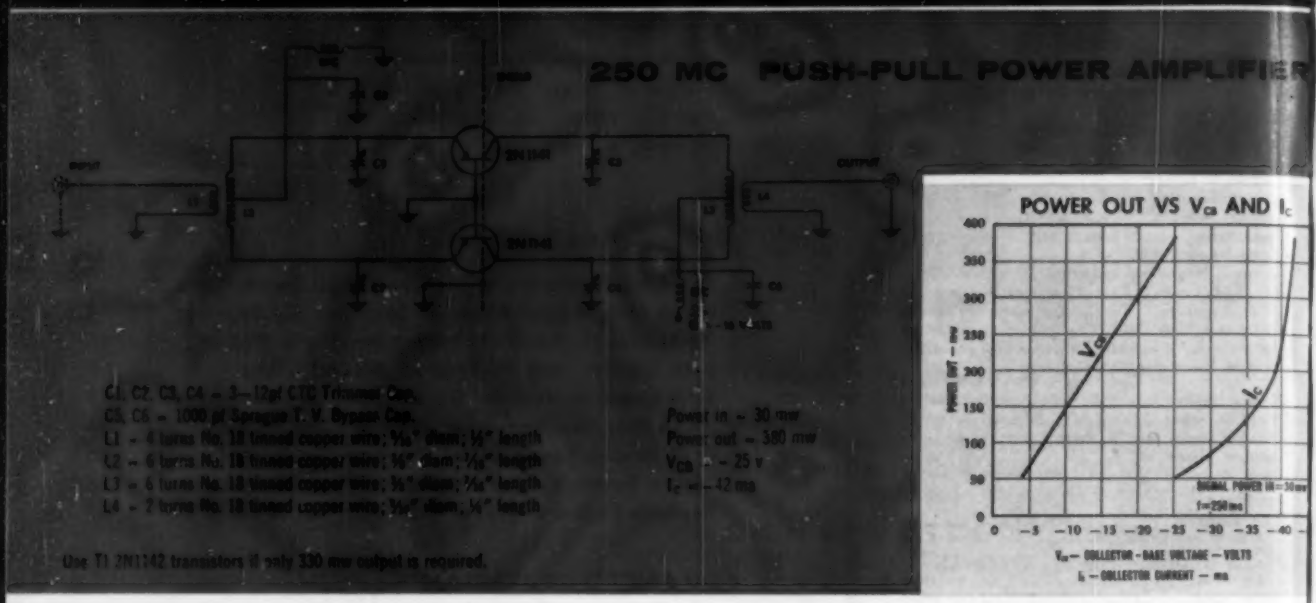
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L3 – 6 turns No. 18 tinned copper wire; 1/8" diam; 1/8" length
L4 – 2 turns No. 18 tinned copper wire; 1/4" diam; 1/4" length
Power in – 30 mw
Power out – 380 mw
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300
250
200
150
100
50
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f = 250 mc
0 –5 –10 –15 –20 –25 –30 –35 –40
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JUDD & DETWEILER's Assistant Production Manager Wayne Warner (center) discusses copy deadlines with M/R News Editor Reed Bundy (left), Copy Editor Dave Newman (standing) and Managing Editor Bill Howard (right).

memo from the publisher

THE FIRST 165 ISSUES of MISSILES AND ROCKETS, beginning in October, 1956, and continuing through last week, were printed by The Telegraph Press in Harrisburg, Pennsylvania. Owned and operated by retired Army generals A. H. and E. J. Stackpole, Telegraph Press has for many years been a very successful book and magazine printing establishment, and has been producing most of the American Aviation Publications since our company was founded in 1938.

With this issue, however, M/R has a new printer: The Judd & Detweiler Company here in Washington, D.C. The gentleman surrounded in the photograph above by several of our more serious-faced editors is Wayne Warner, Assistant Production Manager at Judd & Detweiler, who will be supervising the printing of M/R each week from now on.

Judd & Detweiler achieved national recognition as printers for many years of National Geographic Magazine. They recently attracted our attention by purchasing several new high-speed color presses, and after we had entered into negotiations with them, told us of additional higher-speed rotary press equipment which they will acquire later this year.

Previously hampered by the distance of 125 miles between our offices here in the Nation's Capital and Telegraph Press in Harrisburg, our editors are now enjoying greater flexibility of deadlines, exploiting the 10-minute liaison with the Judd & Detweiler plant, located just a few short blocks away. And since M/R's editorial offices are located within a few blocks of the Pentagon, the White House and Capitol Hill, our "delivery system" of missile/space industry news will be the most efficient by far of any magazine covering the market.

In fact, many East Coast subscribers will be reading the latest missile/space industry news on Friday, just a day after we go to press. Currently under study is a new delivery plan for Midwest and West Coast subscribers which would provide similar high-speed service.

In the future, look for improvements in M/R from a graphic arts standpoint. Illustrations should reproduce with greater detail and contrast. There will be more use of editorial color, more imaginative layouts. After all, just because you read M/R as part of your job doesn't mean we can't make your required reading visually attractive as well as informative.

•

THERE'S USUALLY a story behind every story, and the feature on page 15 is no exception. M/R Propulsion Editor Frank McGuire attended a Los Angeles meeting of the American Society of Metallurgical Engineers last week, and heard N. E. Promisel, Chief Materials Engineer of the Navy's BuWeaps R&D section, deliver a talk on "New Frontiers in Metallurgy." During his address, Promisel made a passing reference to a new process for establishing the inherent ductility of beryllium which set his audience, including McGuire, to squirming in their seats.

Promisel boarded a plane for Washington before he could be cornered for an interview. However, in a fine display of oneupsmanship, Editor McGuire flagged Managing Editor Bill Howard here in our home office, and Bill in turn had Materials Editor John Judge perched on BuWeapsman Promisel's doorstep by the time he reached home base. Result: a fine, exclusive article on a really important materials breakthrough. And proof of the importance of editorial teamwork in covering the fast-moving missile/space industry.

Edward Mukerfeld

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The Countdown

WASHINGTON

The Man in Charge Speaks

President Kennedy's FY '62 defense budget revisions (see page 13) contain some basic policy statements aimed right at the Pentagon E Ring. Sample: "The basic problems facing the world today are not susceptible to a military solution. Neither our strategy nor our psychology as a nation—and certainly not our economy—must become dependent upon the permanent maintenance of a large military establishment."

Atlas Tempo Increases

SAC apparently is speeding up *Atlas* deployment operations. For the first time in a month, Rocketdyne last weekend made pre-delivery checkout runs on boosters late Saturday and Sunday night. Several *Atlas* squadrons are nearing the operational stage.

Water Launch for Saturn?

COUNTDOWN hears NASA-Huntsville is receiving proposals from about 10 companies April 3 on a feasibility study for launching the 1.3-million-lb.-thrust *Saturn* and other heavy space vehicles from offshore facilities—such as ships or Texas towers.

Titan II Squadrons Cut

Chopping of two *Titan II* squadrons in the Kennedy FY '62 budget revision is expected to affect the ones planned for Griffis AFB, N.Y. The reduction means there will be six instead of eight *Titan II* squadrons in all.

Secrecy Lid Grows Tighter

Top DOD officials are clamping a tighter security lid on all advanced weapon systems—starting with *Minuteman*. They indicate that details as to size of programs, funding, etc., will be withheld from the public. Total missile procurement for *Minuteman* beyond the 600 disclosed in the FY '62 budget revision for actual deployment is being kept secret. The ban is expected to spread to tactical missiles going into the production stage.

The Bite of Criticism

Insiders are saying Dr. Clark Randt quit April 1 as NASA's life sciences director because he was unhappy over congressional criticism—notably that of Rep. Emilio Q. Daddario (D-Conn.)

Bid for More Solid Money

Expect the House Space Committee to add-on some more money for NASA's solid rocket booster program—but nowhere near the $30 million asked by two committee members. Kennedy's FY '62 budget revision eliminated extra money for solids requested by NASA and there's a question whether the House Appropriations Committee will go against his recommendation.

INDUSTRY

Missile Cutbacks Hurt

COUNTDOWN hears the Kennedy Administration's decision against going into production of the railroad launcher for *Minuteman* really caught American Machine & Foundry and ACF Industries, the two principal contractors, by surprise. Both were tooled up and waiting for the order to go. It will probably mean some layoffs. Cancellation of the *Eagle* is being felt by Bendix Corp. and its team of contractors, with more layoffs expected.

Tough New Plastic

Researchers at the University of Arizona have come up with a new plastic—polybenzimidazole—stronger and lighter than steel and able to withstand 1200°F. The pure organic fiber reportedly can be cast only after being put into solution.

Electrostatic Gyro Contract

General Electric LMED is developing a new gyroscope with an electrostatic suspension rotor for Jet Propulsion Laboratory under a $195,000 contract. The instrument is expected to provide the extremely high accuracies and long maintenance-free life required for future spacecraft navigation systems.

R&D Intelligence

New Mark 46 tropedo is using a glass-reinforced body, indicative of the trend toward composite materials in "hydrospace" applications. . . . Space Technology Laboratories is under contract to the AFSC to modify *Atlas* and *Titan* boosters to be used as targets for *Nike-Zeus* next year.

INTERNATIONAL

New French Arms Czar

All of the armaments work in the French Defense establishment is being put under one man—General Lavoud. He will supervise all research, development and production for the Air Force, Navy and Army.

Belgium Ready for Space Club

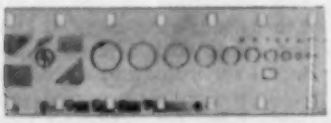
Belgian officials are prepared to contribute $1.1 million annually for five years to participate in the proposed European Space Research program using the *Blue Streak* and *Veronique*—if other countries cooperate. One proviso by the Belgians is that half of their contribution be spent in Belgium.

Overseas Pipeline

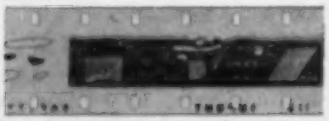
SNECMA of France is submitting proposals to build rocket engines in a cooperative European project. . . . Hector the Space Rat, who traveled more than 100 miles in the nose of a *Veronique* Feb. 22, has sired four little rats. . . . There's a rumor around that Russia already has conducted a successful ballistic rocket shot with a man, and will announce it as sort of an after-thought when it successfully brings a man back from orbit.

NARROW-CHANNEL PHOTOGRAPHY

For people with the problem of photographing the interior of long, narrow channels, Kollmorgen has developed unusual devices capable of recording on film channels as narrow as ½ of an inch.

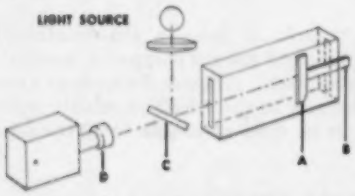


Above, actual size, is a test film of circles and numerals placed within a ½"-wide channel.



Above is a *panoramic* view of a continuous section of the same film . . . with marks enlarged 8x.

Pitting, corrosion, fracture and other defects of interior walls can be continuously recorded with full-dimensional accuracy . . . of exceptional value in quality control operations.



The secret of our insight: A highly precise 45° mirror (A), mounted on a reed (B), is inserted in one end of the channel. A beam splitter (C) directs a powerful light into the channel from the opposite end which is reflected by the mirror onto the sidewall. The photographic leg of the system receives the image from the channel mirror and through the beam splitter. A camera objective (D) focuses the image on the film. The channel is advanced by a carriage in precise synchronization with the advance of film. Result: a continuous, clear photographic record of the entire channel.

Various modifications of this device have been applied to channels up to six feet long. For longer and wider channels we have designed a miniature self-propelled camera, mirror and light source capable of presenting a continuous image on film with resolution sufficient to reveal scratches and hair-line cracks smaller than .010 inch.

If you need special insight on "inaccessible" interiors, or information on other unusual applications of optics/electronics/mechanics—let's talk it over.

Write Dept. 6-4

KOLLMORGEN CORPORATION
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The Missile/Space Week

Air Force Realigns

Air Research and Development Command (ARDC) and the Air Materiel Command (AMC) officially bowed out April 1.

ARDC has been replaced by the Air Force Systems Command (AFSC) with its research operations being taken over by the Air Force Research Command (AFRC). The Air Force Logistics Command replaces AMC. AMC centers which provided logistics support for ARDC divisions will mostly be reassigned to Systems Command.

AFSC, AFRC and AFLC will all report directly to the Air Force Chief of Staff.

Private Satellites Delayed

The Kennedy administration last week reversed the former administration's policy of encouraging private industry to launch communication satellites.

In a space message to Congress, President Kennedy requested deletion of an expected income item of $10 million from the National Aeronautics and Space Administration budget for charges to private industry for satellite launching.

It was understood that the new administration has decided to wait at least a year before deciding what role private industry will play in the operation of communication satellites.

Meanwhile, NASA announced that the British General Post Office has agreed to provide ground stations for transmitting multi-channel telephone, telegraph signals by way of satellites to be launched in 1962 and 1963 under Projects *Relay* and *Rebound*.

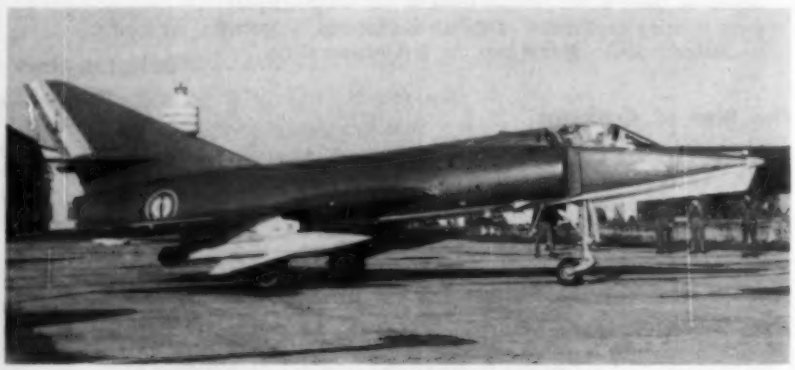
Surveys are under way to determine locations for stations, which will be equipped with advanced tracking and antenna-pointing facilities. The U.S. and Britain indicated they will welcome cooperation by other nations who wish to set up similar facilities.

Single-Managed Electronics?

Recommendation that management of electronic components and repair parts be placed under the single-manager program is currently being studied by DOD. This proposal, urged by the Armed Forces Supply Support Center as a result of a one-year study, is the principal item in the seven-volume Electrical/Electronic Management Report.

The report calls for setting up a jointly staffed Defense Electrical/Electronic Management Center responsible to the Secretary of Defense. The Center would control inventory and procurement of some 650,000 component items with a value of $1 billion. Such a program would be the largest yet considered by the armed forces.

Other recommendations of the as yet unreleased report have to do, primarily, with standardization and inter-



Nord's Ground-to-Air AS 30

NORD-AVIATION'S new AS 30 missile attached to wings of Dassault "Etendard IV" naval strike fighter. The French missile may become rival of Martin's Bullpup.

service coordination of procurement and management.

Shots of the Week:

An improved, 98-foot *Titan* operational prototype flew 5000 miles down the AMR from Cape Canaveral in the third success of the last four launchings. The Air Force missile goes operational this summer.

Also at Canaveral: A *Mace-B* lost power a few seconds after launch and exploded on an isolated tip of the Cape. On March 24, a streamlined *Atlas E* toppled into the ocean about halfway through its full-range test. No mechanical failure was responsible.

Off Canaveral: Nuclear submarine Theodore Roosevelt attempted to launch its first *Polaris* missile while submerged, but the bird suddenly veered out of control and had to be destroyed.

Explorer X Findings

There's much more magnetism in interplanetary space than anyone suspected.

Explorer X, America's optical-pumping magnetometer satellite, has found fields well in excess of two gammas in the region beyond 60,000 miles — an altitude considered by space scientists to be the beginning of interplanetary space.

The 2-gamma finding, recorded by a crude magnetometer aboard *Pioneer V* last year, had been subject to some skepticism on the part of scientists at the National Aeronautics and Space Administration. However, the higher readings by the more sophisticated magnetometer on *P-14*—designated *Explorer X* when it went into orbit—tend to confirm the *Pioneer V* data.

The magnetic data will require a reworking of current ideas of how clouds of protons and other particles travel outward from the sun, both during quiet periods and in solar flares.

Explorer X, which reached apogee of 112,500 statute miles at 3:40 a.m. (EST) March 27—43½ hours after launching from Cape Canaveral —recorded data during a period of relative solar quiet. Thus the increased readings cannot be ascribed to unusual solar activity.

Dr. James P. Heppner, project director at Goddard Space Flight Center, declined to release any of the preliminary readings from the Blossom Point, Md., tracking station until they are confirmed by information from other stations. Tape recordings from these are expected in a few days.

Heppner and other NASA scientists said they consider *Explorer X* a success and are very pleased with the information received. The *Delta* booster launched the spacecraft for its third straight success, reaching an apogee 12,500 miles higher than required. The batteries provided full power for 60½ hours, 5½- more than necessary.

Transmission from the 78-lb. spacecraft continued at full power for 17 hours past apogee, and weak signals for another 3½ hours. Trackers estimated it would reach a perigee of 110 miles over the Western Pacific at 10 p.m. (EST) March 28. However, there was no assurance of any optical sightings to confirm the orbit.

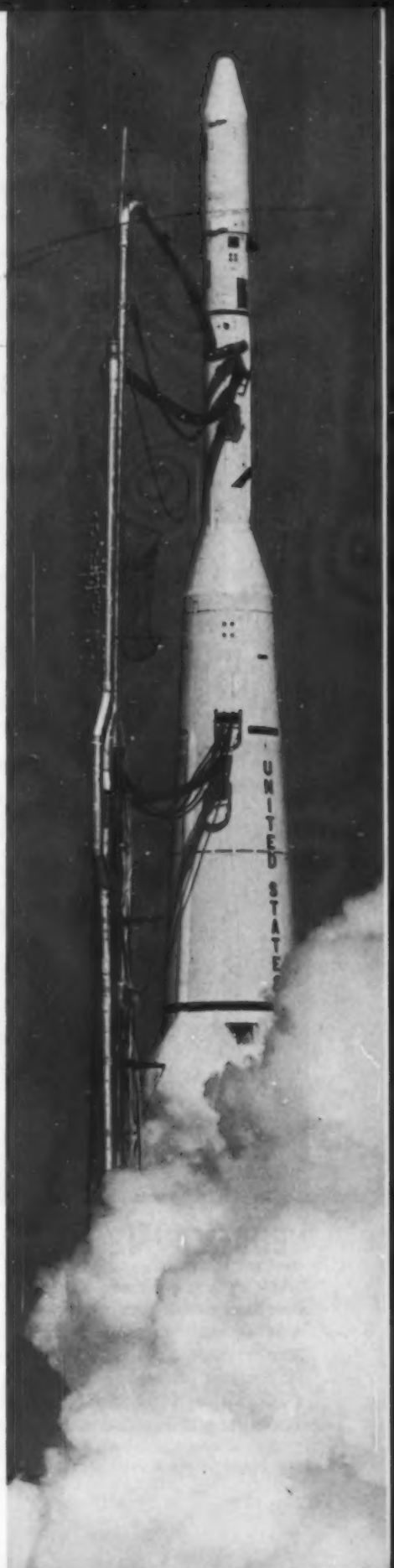
Explorer X's orbit carried it away from the sun and in the general direction of the moon. However, it was about 30° away from a trajectory toward the moon. The next launching of a similar magnetometer will be aboard *Ranger I,* a prototype moon-landing capsule to be sent on an interplanetary trajectory this summer.

AF Asks NORAD Proposals

The Air Force is asking industry for proposals on a development-production contract for an automated NORAD Combat Operations Center. It says proposals are due at Hanscom Field by April 19.

Companies—or teams—desiring the request for proposal must advise the 425L System Program Office (SPO), L. G. Hanscom Field, Bedford, Mass., in writing of their intention no later than April 12. Requests must include team organization (if contemplated), current facility security status of prime or team leader, and statement of experience and qualifications. Verification of current or previously assigned security status by cognizant DOD security agency must also accompany the response.

The 425L system will provide NORAD with a hardened control center for defense of continental U.S. Canada and Alaska against aerospace attack. It will be located six miles south of Colorado Springs.



HIGHLY SUCCESSFUL launch of Explorer X from the Cape on March 25.

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Bold Space Steps Deferred

Kennedy Stresses Step-up of Polaris

by William E. Howard

BIG AND BOLD plans to give the United States a strong military position in space are being shunned by the Kennedy Administration—at least for the present.

Instead, the new commander-in-chief is asking Congress to beef up the ICBM program—chiefly through the addition of 10 *Polaris* submarines—and to expand the nation's limited war capability in non-nuclear armaments.

Sharp revisions were made in the FY '62 Eisenhower Defense Budget in some programs. But the revised budget sent to Capitol Hill last week by President Kennedy generally followed the pattern set by Eisenhower.

The new emphasis is on "insuring" the nation's ability to retaliate in a big war. But it falls short of Air Force arguments for a vast "counterforce" capable of prevailing in any type of war.

Kennedy is requesting an increase of $1.954 billion in new obligational authority, but asked for only an additional $650 million in FY '62 spending. Kennedy said underestimates in spending made by Eisenhower would boost the total spending add-on to $890 million.

Thus the new total for new obligational authority would be $43.794 billion and the new spending figure, $43.8 billion.

• **Missile specifics**—This is what the new budget would do to missile programs:

—Provide $1.340 billion to accelerate *Polaris* submarine production to one-a-month beginning in mid-1963. The additional subs would raise the total authorized to 29, including the five added in January to the FY '61 program. Funds are also recommended to speed up development of the 2500-mile A-3 *Polaris*, train 2500 new crewmen and buy extra missiles for training shots.

—Earmark $96 million to substitute three fixed-base (150 missiles) *Minuteman* squadrons for three train-based squadrons (90 missiles). The money also would be used to double production facilities in existing contractor plants, improve the missile and provide extra ones for training shots. The mobile *Minuteman* program will remain in R&D.

Revised FY '62 defense budget also aims to add limited war capability; Ike pattern followed

—Double *Skybolt* R&D by the addition of $50 million.

—Cancel the last two *Titan II* squadrons (18 missiles) at an immediate saving of $100 million and an overall saving of $270 million.

—Kill the Navy's *Eagle* air-to-air missile at a saving of $57.7 million.

—Phase out the *Snark* at a saving of $6.9 million.

—Cancel installation of *Polaris* on the cruiser Long Beach at a saving of $57.7 million.

Under the revision the Big Four missile programs would give the nation a total of 1301 ICBM's by 1965. The individual totals: *Atlas* — 129 (no change); *Titan*—108 (reduced by 18); *Minuteman*—600 (net increase of 60); *Polaris*—464 (net increase of 160).

Kennedy refused to commit the Army's *Nike-Zeus* antimissile missile to production. Defense officials said flatly that *Zeus* R&D had not advanced to the point where it could be committed to production. This means that Kennedy is following the Eisenhower recommendation to wait until the *Zeus* is tested against ICBM's next year, with the result that if it proves out, the earliest *Zeus* can be deployed is mid-1965.

• **B-70, ANP**—The President's defense plan found general approval in Congress—with the exception of his decision to cut back the B-70 Mach 3 bomber by $138 million and reduce the number of prototypes proposed by Eisenhower from 12 to 4. The new program would permit only the development of the B-70's airframe, engines and bomb-nav systems.

Defense officials indicated the cutback stemmed from a decision that the B-70 does not contribute anything unique to the deterrent force over and above ICBM's and the B-52 bomber fleet.

Also getting the hatchet was the aircraft nuclear propulsion program upon which $1 billion already has been spent. The reduction of ANP to minor R&D had been anticipated (M/R, March 6, p. 9).

Much stress was placed upon better warning systems and enhancing the survivability of SAC's jet bombers. Kennedy requested $44.6 million to place 50% of the 1600 bombers on 15-minute ground alert instead of the present one-third. There was no more money for air alert, however, and no indication that the President would authorize the stockpiling of air alert items.

• **Limited war increase**—NOA for limited war armaments topped $765 million and covered such items as: $129 million for 13,000 more men in the Army, Navy, AF, and Marine Corps; $345 million for a new amphibious transport and other Navy seaborne procurement; $45 million for a joint Air Force-Navy advanced tactical fighter to substitute for the cancelled Missileer; $122 million for more research on development of non-nuclear weapons and $25 million to improve the F-105.

The potential Soviet threat in space was ignored in the President's message. He said only that there were "a number of other space and research programs related to our strategic and continental air defense forces which I find require additional support." The ones enumerated to receive $226 million in new obligational authority were: *Dyna-Soar, Discoverer, Advent, Defender,* missile defense and penetration aids (electronic countermeasures) and "certain other programs" which were not revealed. *Midas,* the infrared missile early warning satellite, was singled out for a $60 million "acceleration" increase.

How much of the $226 million would go to *Dyna-Soar,* the Air Force's orbital space bomber, was not reported in the message. But it was believed to be less than the $100 million requested to accelerate the program by 19 months and provide for the first manned flight by mid-1963.

Taken as a whole, Kennedy's proposals dealt at least a temporary blow to the Air Force in its newly won role as the military space agency. With no money sought for big new booster programs with which to mount a major

manned space exploration effort, the Air Force will be continuing in the satellite-launching role prescribed by Eisenhower.

There were other meaningful hints that Kennedy himself was taking a "second look" at the whole idea of manned space exploration. NASA officials said that their man-in-space program hinged entirely on the success of *Mercury*. Plans to go into hardware on the follow-on *Apollo* spacecraft are being postponed at least until after the first manned *Mercury Redstone* ballistic shot this spring.

President Eisenhower in his parting budget message recommended that the whole man-in-space program be reviewed after *Mercury* to determine whether it was worthwhile to proceed further into space.

Military planners, on the other hand, have insisted that the Soviets are employing their "peaceful" space program to develop strategic systems. These planners contend that the U.S. should move rapidly into space on the theory that whoever controls space also would control the earth.

• **Mobility fight settled** — If Congress goes along with Kennedy's recommendation on *Minuteman*, the Navy's *Polaris* will be the sole long-range, mobile big missile until *Skybolt* comes along. The decision to scratch plans for putting *Minuteman* on trains by 1963 was made both for economy and technical reasons. It is understood that DOD felt the problems associated with jouncing the guidance package over the railroads were far from solved.

Although *Polaris* will not go aboard the Long Beach, DOD did not rule out the possibility of deploying it aboard other surface craft.

The *Polaris* acceleration will mean that the Navy must complete the development of the 1500-mile A-2 model by the spring of next year and have the 2500-mile A-3 ready in the summer of 1963—two years ahead of schedule. This could prove to be one of the roughest hurdles yet encountered by contractors in the program. ⠿

NASA Increase Will Hurry Big Boosters

A MAJOR EFFORT to speed existing big booster programs—and a further deferment of decision on manned space flight beyond Project *Mercury*—are reflected in President Kennedy's request for a $125.67 million addition to the civilian space agency budget.

In a vain effort to balance the civilian portion of his revision of former President Eisenhower's budget, Kennedy sliced $195 million from the $320 million in new obligational authority sought by Space Administrator James E. Webb.

Addition of $16.1 million to the Atomic Energy Commission's budget for space research brought the total increases in the civilian space program to $142.1 million.

Kennedy modified the space program after a series of meetings with Webb, Vice President Lyndon B. Johnson, Presidential Science Adviser Jerome Wiesner, Budget Director David Bell, Deputy NASA Administrator Hugh Dryden and Space Council Director Edward C. Welsh.

• **Place for Apollo**—Although no additional funds were sought for Project *Apollo*, high officials said the new administration has no plan to scrap the project in favor of the Air Force's *Dyna-Soar*. Dryden declared he is convinced there is a place for both *Apollo* and *Dyna-Soar* in the nation's man-in-space plans.

Dryden said the technical staff feels it would be "a little happier if we had *Mercury* under our belt" before making a major decision to go ahead with *Apollo*. Meanwhile, he said, the $29 million of industry research and development provided in the original Eisenhower budget will go for high-speed re-entry tests with *Atlas-Agena B* and *Saturn* launches, further life sciences studies with the *Mercury* capsule, early work on the *Apollo* escape system, mission analysis and research in heating of materials and structures, radiation effects and flight support.

Space Budget at a Glance Fiscal Year 1962

	Eisenhower Budget	Kennedy Budget
	(in millions of dollars)	
New obligational authority	1,119.6	1,235.3
Estimated spending	965	1,050

Major Kennedy Increases

SATURN C-2	$78
CENTAUR	$25.6
ROVER	$14.1*
F-1	$ 9

** Includes increases in AEC budget*

Kennedy also deleted an item of $8 million for solid propulsion studies and something more than $2 million for electrical propulsion. Dryden said both NASA and the Department of Defense are working on solids and both must agree before a new booster development begins. The NASA official said he believes the next step in solids should be a booster about the size of a *Thor* or an *Atas*.

• **Additions**—The largest item in the Kennedy add-on was $78 million to begin development of the *Saturn C-2*. The decision will make it possible to fly the seventh vehicle in 1966 instead of 1967. The shortened development time will make it possible to fly men around the moon in 1968 instead of 1969.

The *Saturn C-2* additions break down to $56 million for developing a new 800,000-lb.-thrust second stage, $11 million to complete work on *Saturn* launch Complex 37 at Cape Canaveral, $4 million for a second static test stand at Huntsville, Ala., and $7 million for additional NASA personnel and plant.

The *Centaur* program, which has run into trouble in the last few months, will get $26.6 million in an all-out drive to make up lost time or, if that proves impossible, at least to prevent further slippage.

The *F-1* single-chamber 1½-million-lb.-thrust liquid engine receives $9 million additional to enable it to meet its schedule of flight rating by 1965.

The *Rover* nuclear rocket program receives $14.1 million to speed reactor and component development — $4.1 million in the NASA budget and $10 million in that of the Atomic Energy Commission. In addition, the AEC receives $6.5 million to speed work on *SNAP* nuclear space power systems.

The budget increase will allow NASA to hire 780 additional employes —460 at Huntsville, 70 at Goddard Space Flight Center, and smaller groups elsewhere—including 180 at aeronautical research centers to work with the Federal Aviation Agency on developing a supersonic transport plane.

• **Cuts and switches**—Two items were cut: $1.05 million from ground instrumentation designed for communication satellites, and $700,000 from plans to build a vivarium to house animals at Ames Research Center.

The budget also showed some juggling of funding between NASA and DOD so that one agency or the other will fund all of a given launch complex at Cape Canaveral. DOD will fund the modification of Complexes 13 and 14 for *Agena* upper stages, while NASA will fund *Centaur* Complete 36B. ⠿

Major breakthrough . . .

Navy Finds Beryllium To be Inherently Ductile

ZONE-REFINED single crystal of beryllium bent at room temperature proved to be free of fracture. Basal plane orientation is indicated. The key to ductility was provided by the application of a zone-refining process.

THE MYSTERY of beryllium's brittle behavior has finally been solved—the metal is inherently ductile.

Previously metallurgists were never sure whether the brittleness stemmed from beryllium itself or from failure to develop optimum metallurgical conditions.

Ductility in single crystals of beryllium is being achieved by researchers at the Franklin Institute, Philadelphia, under a program sponsored by the Bureau of Naval Weapons. (see chart)

Taking the approach that extensive ductility should occur with the removal of trace impurities, a zone refining technique was perfected to purify the beryllium specimens. Details of the process are not yet available.

N. E. Promisel, Chief Materials Engineer, BuWeaps, stressed that the development involved single-crystal beryllium and not the polycrystalline form normally met in structural applications. But he is optimistic about future results.

The crystals were grown so that the basal plane intersected the specimen axis at a 45° angle. Eight passes in the zone refining process resulted in a ductile crystal.

The orientation of the basal plane was required to induce the necessary shear stresses to produce flow in the basal plane. Basal plane cleavage is by far the most prominent and frequent fracture mode in beryllium.

If distortion in shear without fracture could be achieved after refining, then the brittleness of beryllium could be laid to impurities.

• **Oxygen's innocence?** — Project spokesmen say that the exact degree of purity in the refined crystals has not yet been determined. They are positive that all of the oxygen was not eliminated.

Future work at Franklin will define the significant impurities by recontaminating the zone-melted crystals. These studies will also include polycrystalline beryllium.

Apart from the purification route, the Navy has had some degree of success in forming ductile beryllium wire. The key here was the proper orientation of the grain.

Composite processes, involving beryllium in a ductile matrix of silver or aluminum, led to specimens capable of a 75% cold reduction at room temperature. Such specimens suffered in strength but not in modulus or heat capacity.

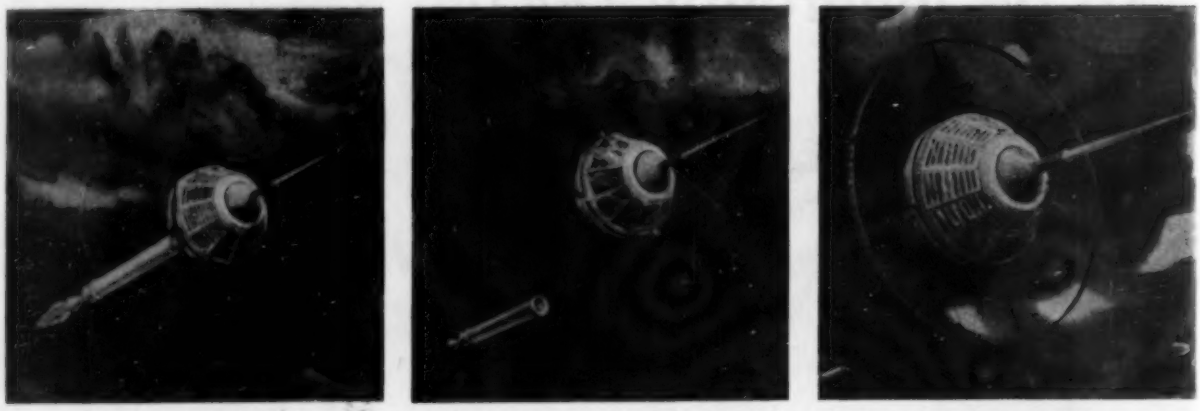
The single-crystal approach has been suggested by various investigators. But the adaptation of zone-refining techniques to beryllium crystals represents an additional step in the usual procedures. The program has been in operation at Franklin Institute for a little over 18 months; most of this time was spent in modifying zone melting methods to fit the task. ⌗

Tensile Tests of Zone-Refined Beryllium Crystals

BASAL PLANE ANGLE TO THE LONG AXIS OF THE TEST BAR	NUMBER OF ZONE PASSES	SLIP SYSTEM	REDUCTION IN AREA %	ELONG. IN ½ INCH %	GLIDE STRAIN	SHEAR STRESS BASAL (0001) PSI
45°	Reference Melted Crystal	Basal	<1	<1		2500
45°	2	Basal	8.0	8.1	18	1750
45°	8	Basal	50.2	100	160	500

S-45 Will be Studied around the Globe

Five major scientific groups will cooperate with NASA when second try is made in late spring to launch ionosphere craft



ARTIST'S CONCEPTION of the launching sequence of the pay load of the S-45 Ionosphere Beacon Satellite.

by Jay Holmes

THE UNITED STATES is inviting scientists around the world to conduct ionosphere experiments by studying signal reception from the *S-45* ionosphere beacon satellite.

Another attempt will be made in late spring to launch *S-45* with the final *Juno II* vehicle. The first attempt on Feb. 24 was spoiled by an upper-stage failure.

The spacecraft, weighing 75 lbs., consists of a crystal oscillator powered by solar cells and rechargeable batteries designed to transmit on six frequencies continuously for 13 months. Its orbit will be highly elliptical—from 240 to 1600 statute miles—so as to obtain information from various areas of the Van Allen radiation belts.

Experimenters on the ground will be able to draw extensive conclusions on the daily and seasonal variations of the ionosphere—as well as the effect of solar activity—by studying variations in the quality of the signals received. They also will be able to draw conclusions about the effect of the earth's magnetic field on the ionosphere and about time variations in the magnetic field.

During the International Geophysical Year, scientists discovered with rocket flights in the Arctic that solar particles disturb the low-altitude D-layer of the ionosphere. At higher altitudes, the disturbance results from electromagnetic radiation in the ultraviolet and X-ray spectral regions. Profiles of electron density—a standard measurement of ionosphere quality—were obtained in detail up to about 150 miles altitude. However, only a few measurements above that altitude—to about 300 miles—were obtained by Soviet and American rockets and satellites.

The indication from the information available to date is that during the day the D, E, and F ionosphere layers blend together and separate again by night. However, much more data is needed before firm conclusions can be drawn.

• **Broad cooperation**—Five major scientific groups already have arranged to cooperate with the National Aeronautics and Space Administration in observing the transmissions from *S-45* on frequencies of 20.005 mc, 40.010 mc, 41.01025 mc, 108.027 mc, 360.09 mc and 960.240 mc—all harmonically related to the basic oscillator frequency of 1.00025 mc, stable to one part in 10 million for periods of a half-hour.

The frequencies of 20, 40 and 41 mc, radiated by a loop antenna 6 ft. in diameter, will be polarized perpendicular to the axis of spin of the satellite. The other three frequencies, radiated by rod antennas, will be polarized along the spin axis.

The major observations to be made are the Faraday effect and the Doppler effect on the transmissions. The Faraday effect rotates the polarization of a signal as it passes through an ionized region. The amount of rotation depends on the frequency of the signal, the magnetic field strength, the direction of the signal and the density of electrons along the path.

By receiving the signal with two antennas on the ground at right angles the rotation of polarization can be determined. The aspect of the satellite itself is telemetered to the ground separately. Aspect can also be established by comparative measurement of signal amplitudes on the various frequencies.

The Doppler effect varies the frequency received on the ground according to the velocity of the satellite with respect to the ground station. If there are no electrons between the satellite and the station, the frequencies received vary in the same proportion as those transmitted.

However, the presence of electrons in the ionosphere affects the various frequencies differently. By comparing effects on the different frequencies, by a process called differential Doppler, scientists can compute the electron density. Such a process requires making certain assumptions, however. To avoid the necessity for making assumptions, one experimenter is measuring the differential Doppler at two stations separated by more than 100 miles, NASA said.

• **Experiments**—The five principal investigators are Dr. W. J. Ross of Pennsylvania State University, R. S. Laurence of the National Bureau of Standards, F. de Mendonca of Stanford University, Dr. G. W. Swenson of the University of Illinois, and Dr. J. E. Titheridge of the University of Auckland, New Zealand.

The Penn State experiment calls for receiving *S-45* signals at University Park, Pa., and Huancayo, Peru, and comparing them with similar signals from *Sputnik III*, the U.S. Navy's

Transit satellites and future Soviet *Sputniks*. Penn State will pay particular attention to signals received at night and to low-altitude passes. In conjunction with the 23 months of records from *Sputnik III*, Penn State will seek to evaluate the effect of the solar cycle on the total ionosphere. Doppler effect methods will be used.

Ross also plans to study the phenomenon of phase scintillation of satellite signals, so as to determine the structure, location and occurrence of irregularities in the ionosphere.

The National Bureau of Standards, at its Central Radio Propagation Laboratory in Boulder, Colo., plans to use the Faraday effect to study daily and seasonal variations. By measuring the amplitude and angle of signal arrival, NBS plans to plot irregularities.

NBS plans to compare its results with 20 mc signals from the new satellite with similar results it attained with 20 mc signals from *Sputnik III*. An ambiguity in the method of analysis prevented establishment of the total electron content of the ionosphere from *Sputnik III* data. However, NBS plans to remove the ambiguity by comparison with *S-45* results on 40 and 41 mc.

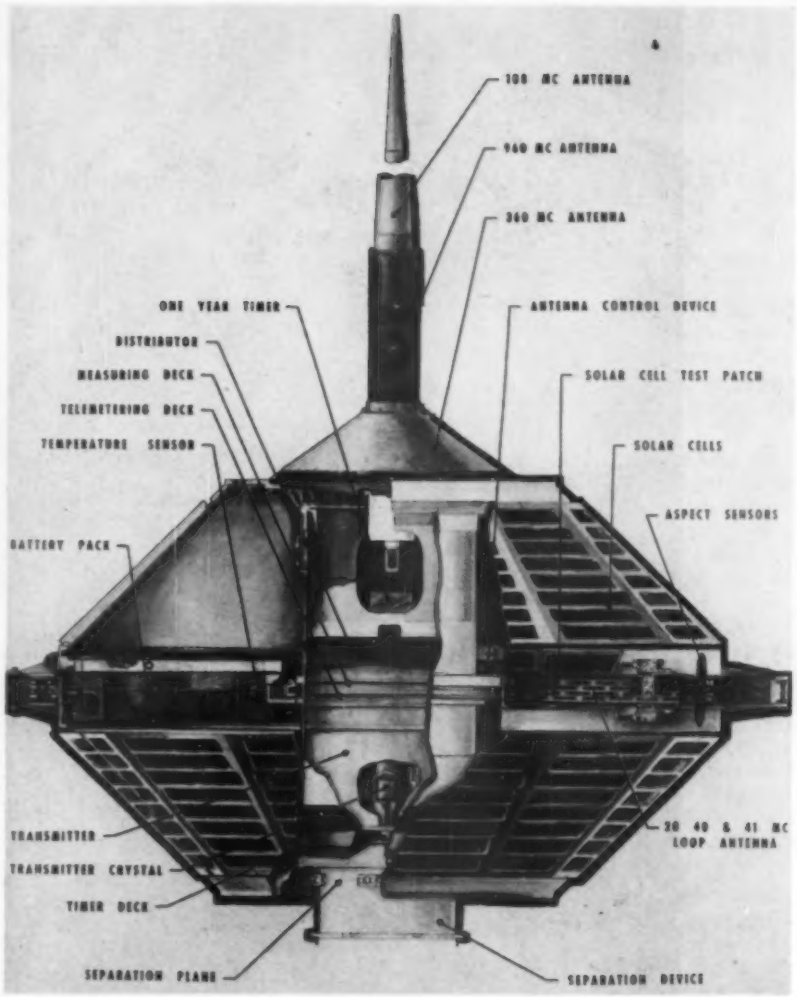
The Stanford University Electronics Laboratory will make observations at the university and at the University of Hawaii. Both Faraday and Doppler methods will be used to study the effects of solar and magnetic storms on the electron content of the ionosphere and of the size and times of occurrence of ionospheric irregularities.

Stanford also will study long-range radio propagation, including reception at the antipodal point—on the other side of the earth from the point of transmission—as well as multi-hop and tilt-mode propagation from the satellite.

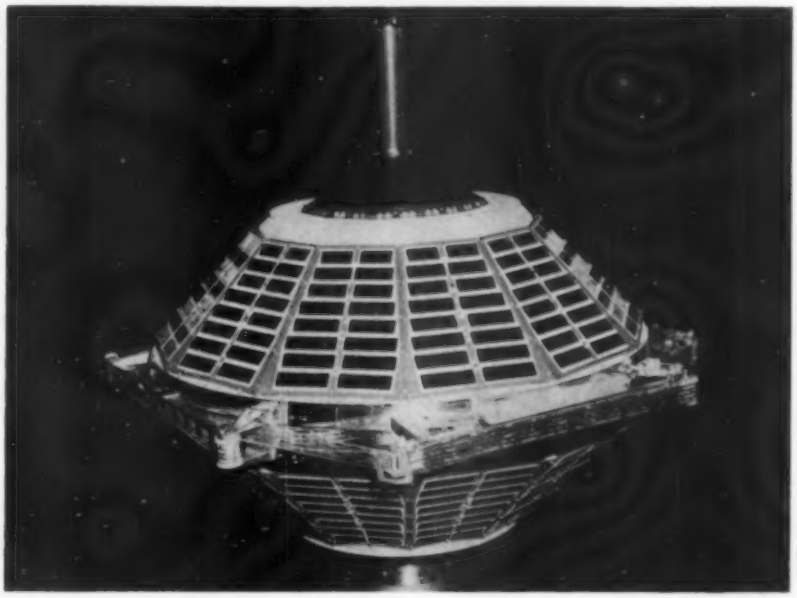
The University of Illinois will concentrate on scintillations in signals from the satellite, caused by an ionosphere region above 145 miles altitude and north of the 40th parallel. Measurements will also be made with receivers spaced some distance apart. A third area of study will be the determination of total electron content of the ionosphere from Faraday rotation.

The Seagrove Radio Research Station of the University of Auckland will concentrate on the bearing and elevation angle of antipodal signals from the satellite. A radio frequency interferometer to be used will have one fixed axis and—in an unusual technique—one axis that rotates in the horizontal plane.

New Zealand has a particular interest in antipodal signals because a great part of the country's communication with the rest of the world depends on antipodal radio reception. ⌗



ABOVE: *Major parts of the S-45 Ionosphere Beacon Satellite shown in cutaway. Solar cells and rechargeable batteries power crystal oscillator capable of transmitting on six frequencies continuously for 13 months. Three frequencies are polarized perpendicular to axis of spin, three along axis.* **BELOW:** *Exterior view.*



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new data on stars . . .

S-15 to Hunt for Gamma Radiation

THE GAMMA RAY astronomy telescope satellite—designated *S-15* is expected to be launched soon.

The 82-lb. *S-15*, a box and cylinder combination 44 in. long and with diameter varying between 6 and 12 in., was to be launched by a *Juno II* vehicle from Cape Canaveral into an orbit varying between 300 and 600 statute miles altitude (see report in M/R, Feb. 6, p. 24).

Tumbling end over end at a controlled rate of about 10 rpm, the satellite's telescope is to scan the sky for radiation in the very-short-wavelength gamma ray region—which is absorbed by the atmosphere and thus never reaches the earth. The intensity and nature of gamma radiation from the stars can provide astronomers with a great deal more information about their nature.

The telescope, designed by Massachusetts Institute of Technology for the National Aeronautics and Space Administration, operates on the coincidence principle, since it is impossible to focus the highly penetrating gamma radiation with reflecting surfaces. Two Cerenkov scintillators are placed at opposite ends of the telescope tube and the circuitry is arranged so that only radiation that strikes both scintillators is counted. Thus it measures only radiation entering the telescope along its longitudinal direction.

The source of gamma radiation—which is electromagnetic—can be determined exactly from the direction. This is untrue of particles such as protons and electrons, whose path is curved by magnetic fields in space.

The satellite will remain attached to the 12.8-lb. empty fourth-stage motor casing, which will add an additional 44 in. in length. A section of the transmitting antenna will add length and weight to help achieve the tumbling action.

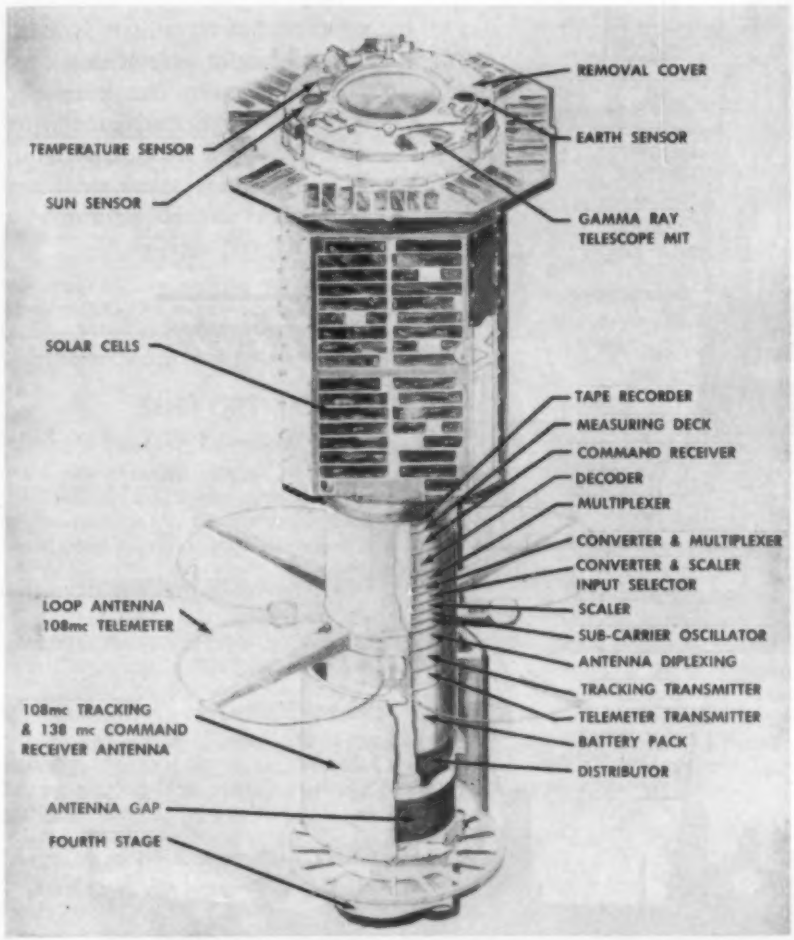
An unusual damping mechanism is built into an adapter at the aft end motor case to control the tumbling. Like all payloads boosted by *Juno II*, the satellite will be spinning at about 380 rpm when injected into orbit. The spin gradually slows in orbit as a result of magnetic and frictional forces but under normal conditions this occurs very slowly and at a rate that cannot be predicted accurately.

The slowing of the spin rate introduces the tumbling by the action of gyroscopic precession. However, the *S-15* motor case adapter has a container of mercury, which expands under the heat of the rocket motor. The expansion moves the heavy mercury outward, increasing the moment of inertia and slowing the rate of spin. As a result, the tumbling begins immediately.

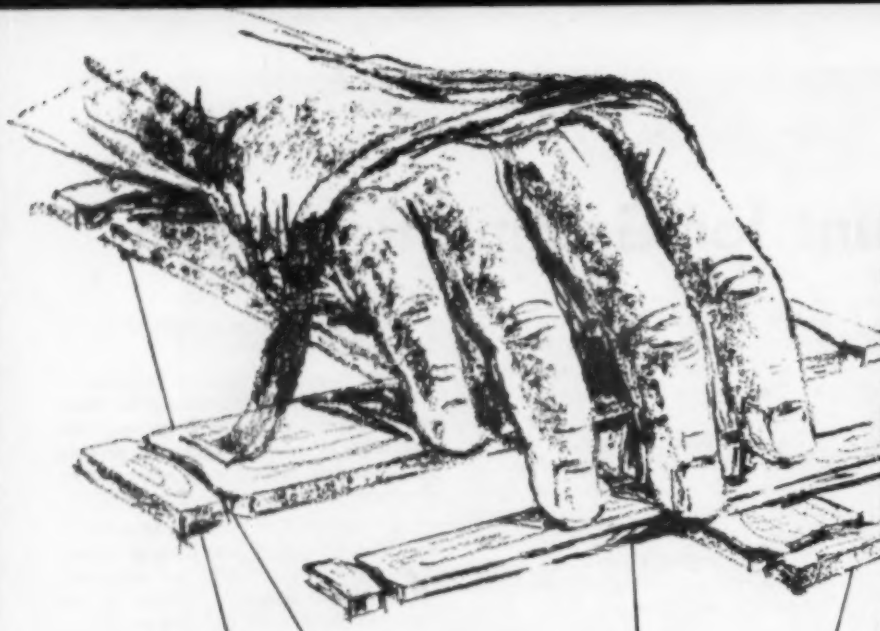
Signals from sun and earth sensors will enable a computer on the ground to compute the satellite's orientation at any given moment and thus the direction of the gamma radiation.

The satellite will carry two transmitters. One will radiate 125 mw on 107.97 mc from four loop antennas around the housing with tape-recorded data on command from ground stations in the Minitrack network. A tracking beacon will operate on 108.06 mc with power of 20-25 mw. Solar cells will recharge the 12 nickel cadmium batteries for an expected life of more than six months.

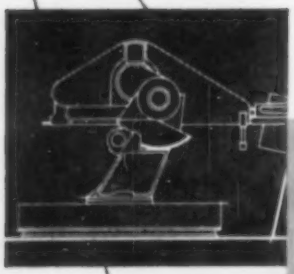
The selected orbit, at an inclination of 28° to the equator, was chosen so that the telescope will scan the sun during the early part of its lifetime and so that an appreciable fraction of time will be spent below the inner Van Allen belt, so as to minimize radiation damage to the solar cells. ⌗

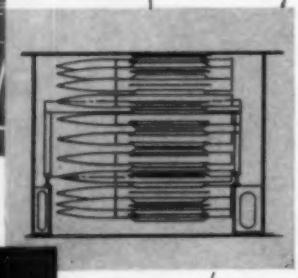


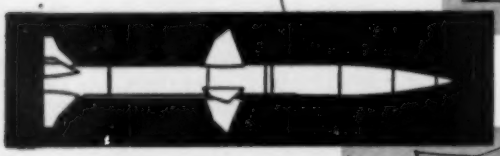
ARTIST'S CONCEPTION of NASA's S-15 gamma ray astronomy telescope satellite.

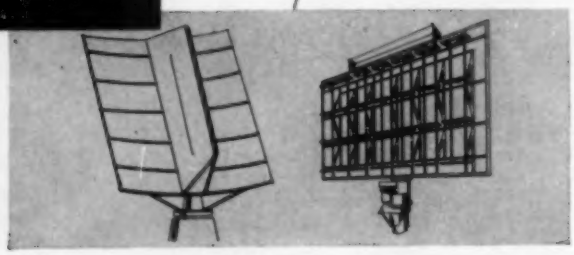


IT'S THE MAN BEHIND THE SCENE WHO COUNTS



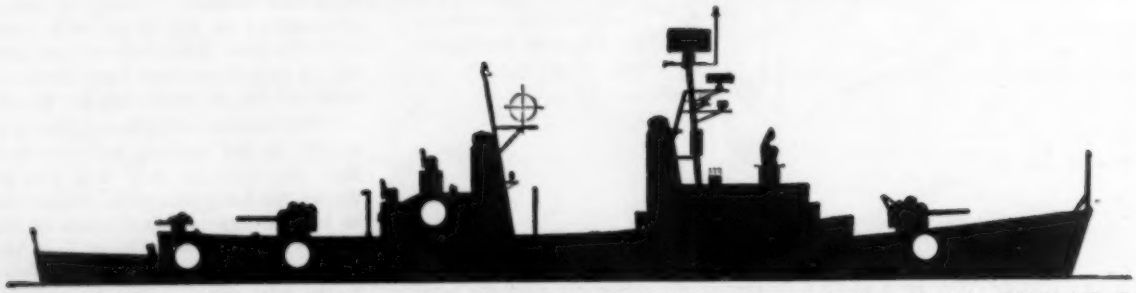






Vitro has performed the little-known but important role of systems engineering coordinator on more than 60 military systems. Take a careful look at this function – integrating components of complex range instrumentation and shipboard weapon systems. This backstage assignment has resulted in "on-time" performance to the military services.

Vitro



VITRO LABORATORIES/Division of Vitro Corporation of America/SILVER SPRING, MD. • WEST ORANGE, N.J. • EGLIN AFB, FLA.

Technical Countdown

ELECTRONICS

Low-Cost Micro-units Developed

Low cost and high-volume production of microminiaturized modules is reported by Burroughs Corp. with its new BIPCO units. First production model—a binary-to-decimal converter—is about the size of a postage stamp and contains 40 silicon diodes with circuitry and mounting. Units are priced at $45 in small quantities.

Japanese Electronics Imports Climb

The U.S. imported $94 million worth of Japanese electronic products in 1960—a 24% gain over last year. Biggest items were commercial products—radios, recorders, speakers—but substantial gains were also posted in tubes, transistors, and other components. Electronic Industries Association is taking a hard look at this trend and may fight to limit such imports to protect its member companies.

New Use for Satellites

A signal from *Tiros II* was used by RCA to trigger an explosive charge to break ground for its new advanced space environment center at Princeton, N.J. The weather satellite was built there by the Astro-Electronics Division, which will occupy the multimillion-dollar facility when completed.

Cyrogenic Delay Line in Development

Air Force has awarded a $90,000 contract to The Martin Co. for development of a superconducting 20 musec cryogenic delay line operating between 4 and 12 gc. The line is to be encapsulated in a 3-in cube and maintained at a temperature within four degrees of absolute zero.

Fuel Cells Slated for Orbit Test

Flight testing of fuel cells as auxiliary power sources for satellites is scheduled for the "near future." General Electric MSVD is working on three regenerative hydrox cells for the AFSC (Air Force Systems Command) test program. Units are designed for 50-watt output.

SUPPORT EQUIPMENT

World's Fastest Camera?

A new research camera developed by STL has shutter speeds of up to 2.5 nanoseconds. To be used in the study of plasma physics, the ultrahigh-speed camera is shuttered electronically by a special RCA-built image-converter tube.

Antenna Market Grows

An indication of the size of the radio-radar antenna market is one company's estimate that 35 companies received contracts of $100,000 or more in 1960.

Research in Fuel Cells Expands

Private research in fuel cells is running to $15 million annually. Anthony Moos, of Leesona Corp., foresees applications ranging from 1000 kw ground power units to automobile engines.

Measurement Committee Proposed

Work is going forward on the organization of an intersociety technical committee for precision measurement and standards. Sponsored by the George Washington University Center for Measurement Science, the proposed group has been okayed by AIEE, IRE, ISA, ASME, ASTM, and representatives of DOD, Bureau of Standards, and other government agencies. Support of IAS and ARS is now being sought.

ASTRONAUTICS

Einstein vs. Fitzgerald-Lorentz

Final answer to which theory of the velocity of light—Einstein or Fitzgerald-Lorentz—is correct may come from a series of observations made between 1878 and 1900. Recent analyses of the study showed unexplained variations in the observed timing of eclipses of Jupiter's moons. These variations, some investigators feel, may be caused partly by different light velocities out and back. If so, the fact would support validity of the Fitzgerald-Lorentz contraction theory in opposition to Einstein's relativity theory.

Rotochute Tests Successful

Kaman's Rotochute re-entry/recovery device has successfully passed transonic wind-tunnel deployment tests at Arnold Engineering Development Center. Still to be solved in the AFSC project is problem of controlling vehicle's descent rate and direction.

ADVANCED MATERIALS

Polyurethane for Heat Shield

AFSC is experimenting with a sprayed-on polyurethane coating to protect air-to-surface missiles from thermal radiation. Coating will also be used on aircraft for protection against heat of nuclear blasts and that generated by its own missiles when fired.

Plastics Fail in Mockup Scheme

Vehicle mockups using all-plastic construction with metal tie-rods have been virtually discarded—after considerable effort to make them a feasible substitute for plaster and other materials. Several firms reportedly found the necessary epoxy resin hard to work with; the resulting fourfold cost over plaster prompted gradual disinterest in the scheme.

New Material Strongest above 1800° C.

Boron Pyralloy, said to be 70% stronger than pyrolitic graphite, has been developed by High Temperature Materials, Inc. The new substance has a room-temperature bend strength of 37,000 psi, comparing favorably with many aluminum alloys. Thermal properties are such that Pyralloy provides a 4000°F temperature drop over a 1/20 in. thickness. Its use makes it possible to reduce both size and weight.

Helium-3 Used in Cryostat

Westinghouse scientists are using helium-3 to reach temperatures from 0.3° to 1.0° A in a routine fashion. The rare gas is released in the gradual decay of tritium or hydrogen-3 and in hydrogen fusion. Four liters of helium isotope cost about $500, even after a tenfold price reduction.

PROPULSION

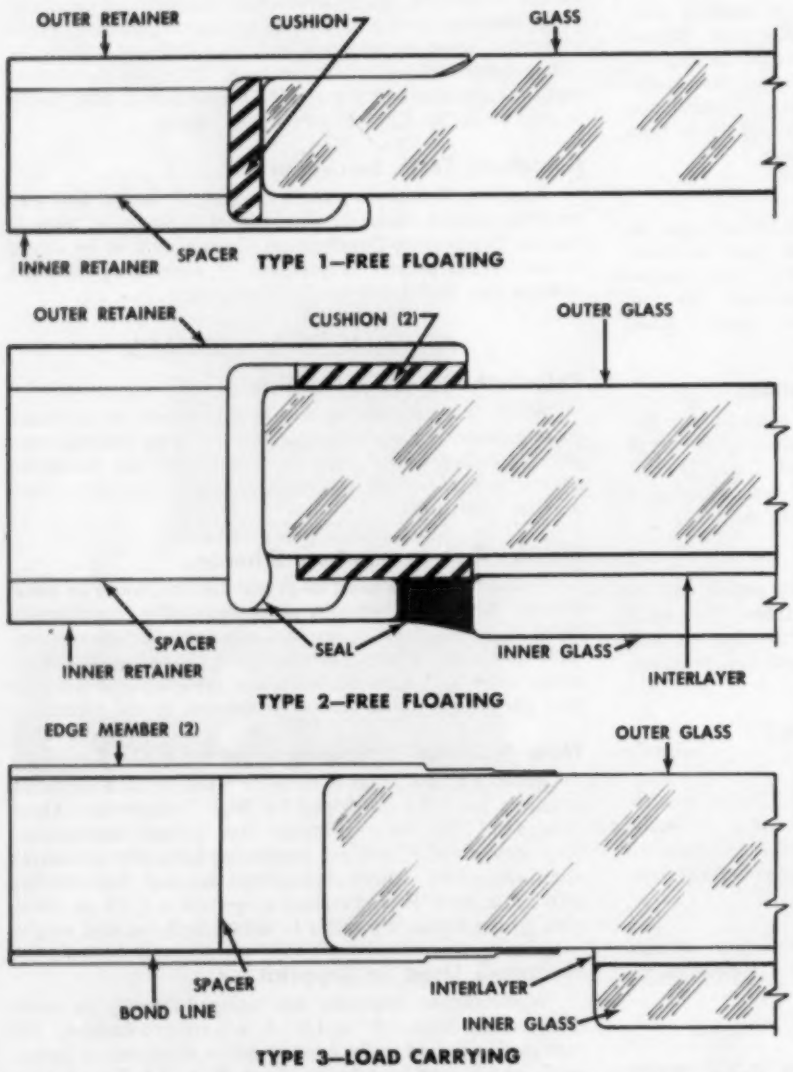
Titan II on Rush Schedule

Turbopump drive assemblies for *Titan II* engines were moved from drawing board to tested prototype within eight weeks by Western Gear Corp. during an all-out, around-the-clock effort to supply Aerojet with the critical components.

AF Presses Work on Vehicle Windows

Corning reports on research with alumino-silicate glass and Narmco study of mounting techniques

by John F. Judge



NARMCO'S STUDIES led to three mounting designs. Type 1 is for a free-floating, monolithic 1723 glazing incorporating two novel techniques. A landed shoulder edge with the re-entrant condition was included and edge cushioning between the frame and the glass was eliminated. The Type 2 attachment is more conventional, using a silicone rubber cushion and seal between the free-floating laminated glazing and frame.

The Type 3 attachment is an example of the most controversial glass mounting, in that it deliberately transfers tensile loads to the glass by means of bonded side members. But the specimen tests consistently achieved higher loads than were called for in the contract. All three were concerned with 1723 glazing, an alumino-silicate glass.

THE AIR FORCE is growing increasingly interested in an almost forgotten aspect of manned aerospace vehicles—direct vision windows.

Operational and environmental conditions affecting glazings in future vehicle designs were presented to 33 representatives from the missile/space industry by Corning Glass Works at a recent symposium.

Corning reported on an Air Force contract involving the properties of alumino-silicate glass (CGW Code 1723). The maximum service temperature of this material is 900°F, but because future requirements will go far beyond this, the work also covered high silica glass (CGW Code 7900) and fused silica (CGW Code 7940).

A companion program involving high-temperature glazing edge attachments and techniques under development at Narmco Industries, Inc., was included in the presentation.

• **Psychological necessity**—In the opinion of designers and fabricators, the need for visual reference in future manned aerospace vehicles is nonexistent from a structural and aerodynamical viewpoint. But there is almost universal agreement that some degree of external vision is a psychological must.

For this purpose, radar, periscopes, television and direct vision may be included. With the exception of radar, all of these require some sort of transparent skin area on the surface of the vehicle.

Forgetting the pilot for a moment, there will always be a need for more transparent and semi-transparent skin areas for cameras, solar batteries, and infrared and ultraviolet detectors.

The optical quality of these glazing materials must be excellent if they are used for high-resolution optical instruments. This means that no distortions may be introduced by the mounting airframe loads.

In the vehicles in question, no unnecessary protrusions from the basic fuselage lines can be tolerated. Thus

the glazings involved will conform to the vehicle—large radii of curvature and small degree of arc.

The intrinsic strength of glazings is quite high, but the working tensile strength is usually very low, because of stress concentration effects caused by minute surface imperfections or improper mounting. The larger and heavier the glazing, the lower the allowable working stresses will be. Corning points out that maximum working stresses must be determined for each specific application.

In a composite structure such as a pilots' enclosure, the design must keep to a minimum stress concentration due to mounting and attachment joints. In addition, the expansion characteristics of the glazing and framing materials should be matched as closely as possible over the expected temperature range. Where this cannot be done, compressive stresses should be induced on the glazing during the duty cycle.

Pressures from opposite surfaces of mounting frames should be uniform around the periphery end, and an intermediate resilient material should be used to prevent direct metal contact. To avoid stress concentrations and abrupt loading conditions, the edges of the frames glazings should be chamfered or radiused and the corners well rounded.

Localized temperature gradients between opposite surfaces of a glazing can induce excessive stresses. But the linear coefficients of the glasses under consideration are low enough so that the maximum stress at the surface, especially with a controlled temperature gradient, should not be great enough to cause failure.

• **Heat factors**—The thermal environments experienced by a vehicle obviously depend upon its mission. The maximum operating temperature of any craft utilizing transparent enclosures is limited by either the glazing or the sealing and framing materials. The qualities of the three glazing materials under investigation lead to the assumption that the major thermal limitations will be imposed by the surrounding structural media.

The aerodynamic load imposed on a particular external glazing will be determined by its location on the vehicle and by the vehicle configuration. The actual loads are difficult to predict in advance of flight-testing; the designer must include both near frontal and nonfrontal capabilities. Where positive compartment pressure is indicated, several other problems are introduced. If a multiple glazing system is used, compartment pressure could be retained by the inside glazing, where the temperature is lower and conventional organic sealant materials can be employed.

Alloys Under Consideration for Framing Materials

ALLOY GROUP	ALLOY	DENSITY (LB./CU. IN.)	PRINCIPAL COMPOSITION	SOURCES
ALUMINUM	Not Covered			
MAGNESIUM	Not Covered			
ALLOY STEEL	Vascojet 1000	0.280	Fe-Cr-Mo	Vanadium Alloys
	Potomac A	0.283	Fe-Cr-Mo	Allegheny Ludlum
TITANIUM	Comm. Pure	0.164	Ti	—
	6A1-4Va	0.161	Ti-Al-Va	Armour Research
ST. STEEL	AISI 310	0.284	Fe-Cr-Ni-Mn	—
PRECIPITATION HARDENED S.S.	17-7Ph/TH1050	0.277	Fe-Cr-Ni	Armco
	Ph15-7Mo/RH950	0.277	Fe-Cr-Ni-Mo	Armco
IRON-BASE HIGH-TEMP.	A-286	0.286	Fe-Ni-Cr	Allegheny Ludlum
NICKEL-BASE HIGH-TEMP.	Hastelloy X	0.297	Ni-Cr-Fe-Mo	Haynes Stellite
	R-235	0.310	Ni-Cr-Fe-Mo	Haynes Stellite
	René 41	0.296	Ni-Cr-Co-Mo	General Electric
	Inco 700	0.295	Ni-Co-Cr	Inco
	M-252	0.298	Ni-Cr-Co-Mo	Carboloy, G.E.
	Udimet 600	0.286	Ni-Cr-Co	Utica
COBALT-BASE HIGH-TEMP.	L-605	0.330	Co-Cr-W-Ni	Haynes Stellite
REFRACTORY ALLOYS	0.5% Ti-Molybdenum	0.369	Mo-Ti	Climax Molybdenum
	F44/F48 Columbium	0.368	Cb (?)	General Electric

Depending upon glazing size and configuration, the loads imposed by compartment pressure will take the form of plate bending, hoop tension, or a combination of both. For the latter two conditions, a definite load-carrying edge attachment member is needed.

• **Insulation or heat sink**—With maximum skin surface temperatures ranging from 900° to 2000°F for periods of a few minutes to several hours, methods must be found to restrict or dissipate heat flow. The engineers contacted by Corning during the survey completely endorsed a multiple-glazed system.

But Corning specialists say that such a system can adequately reduce the heat flow only by resorting to an exorbitant number of glazings or incorporating cooling or insulating devices.

These include metal shields which cover the glazings during peak heating; circulation of air or liquid coolants between glazings, heat-reflective coatings and combinations of all three.

The use of metal shields in frontal applications can be considered a necessity. But circulating media, gaseous or liquid, introduce the problem of seals. If the medium is liquid, the glazing will be subjected to added inertia and surge loads and a possible change in the index of refraction caused by density variations. Since it is almost impossible to heat a liquid uniformly, the convection currents would degrade the optics of the system. To a lesser degree, the same effects would hold with gaseous coolants.

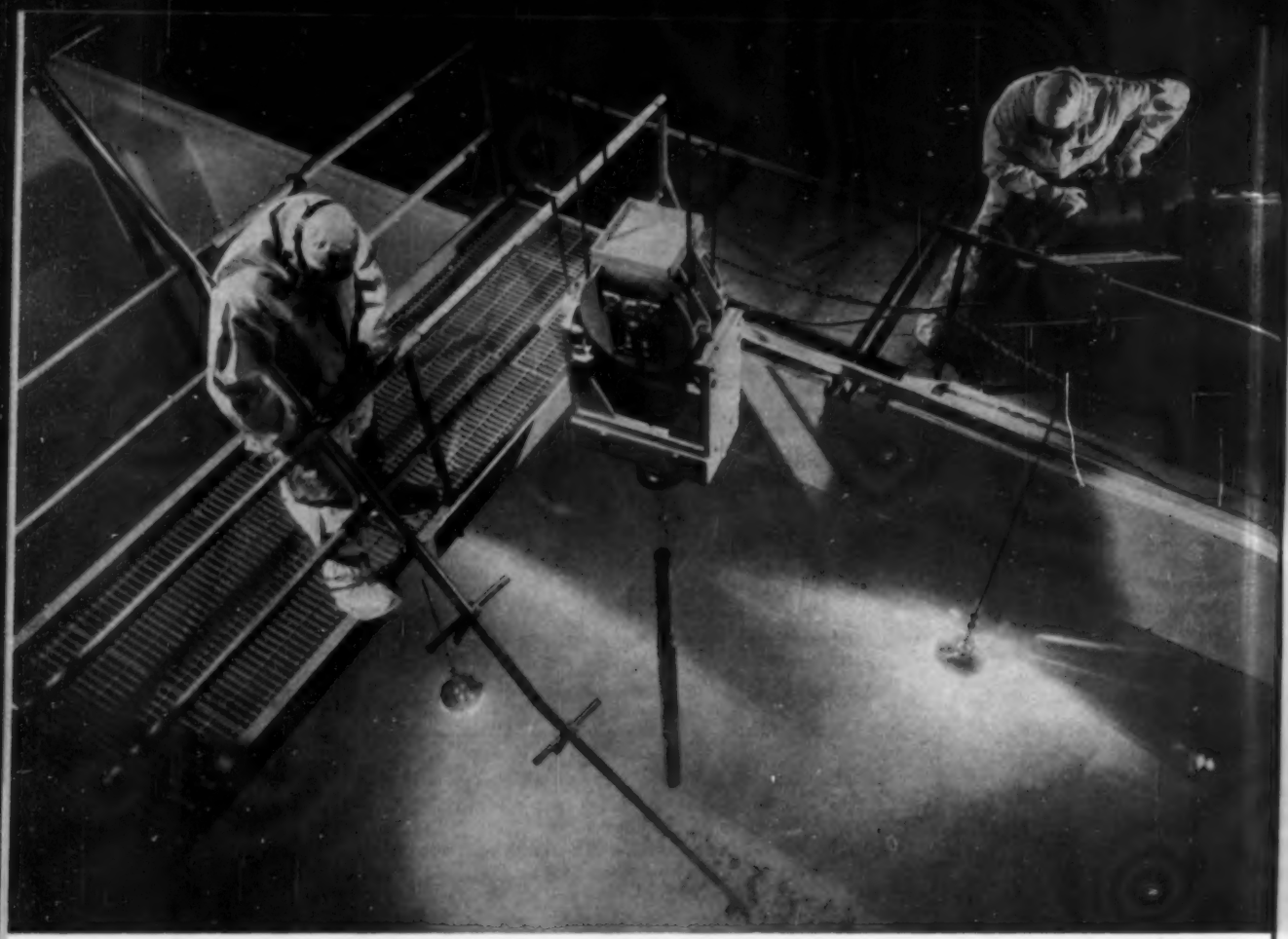
Depending on the material, the primary means of heat transfer through a glazing is either by direct radiation transmission or absorption and reradiation of the thermal energy. In either case, the obvious method or retarding transfer would be through infrared reflective coatings. But these coatings tend to reduce visible light transmission and increase surface reflectance. Methods are being devised to increase the IR reflectance of the coatings and eliminate the absorption of certain IR wavelengths. These results will have a definite influence on edge attachment and mounting system design.

Another path for heat transfer is by conduction through the frame surrounding the glazings. Since the aerodynamic boundary layer comprises a source of an essentially infinite amount of heat, this can be a problem of some magnitude. Due to the high temperatures and long soak times involved, simple heat sink devices or thermal insulation systems will not, by themselves, provide adequate cooling. Incorporation of long, small cross-sectioned heat paths and thermal barriers, together with a circulating liquid coolant, can offer a satisfactory solution.

Differential thermal expansion, thermal shock and stresses were also considered. The glasses in question offer no problems in themselves in this area: it is the mountings that will cause trouble.

• **Materials compatability**—The choice of materials for elevated temperature glazing installations is depend-

(Continued on page 43)



NASA Puts New Reactor to Work

EFFECT OF RADIATION on materials at liquid hydrogen temperature of −428°F will be one of the first problems to be investigated by NASA's new Plum Brook Reactor at Sandusky, Ohio, views of which are shown in the accompanying pictures. Above, a Hot Lab technician operates an underwater handling tool while another removes a control rod from the reactor to an underwater storage area. At right is the interior of containment tank. The operator at upper center is running hydraulic tests to determine water flow distribution in the reactor core. During reactor operation, the pie-shaped area will be filled with about 25 ft. of water.

Other experiments to be scheduled in the early phase of reactor operation will determine the effects of radiation on material corrosion rates at high temperatures and on sensitive electronic components. All experiments will have bearing on plans for the Project *Rover* nuclear rocket or the *SNAP* series of nuclear space powerplants, both of which are under the combined sponsorship of NASA and the Atomic Energy Commission.

Under a license granted by the AEC, NASA is beginning to operate the reactor on a low-power calibration basis. After several months of operation at low power, it will move up to full power of 60 thermal megawatts. The reactor is cooled and moderated by light water, with a primary beryllium reflector and a secondary water reflector. The core consists of 27 aluminum-uranium rods. ¤

RCA 110 Control Computer

masters 3,000 checkout or control points per second..."as is"!

For space age requirements in checkout, data reduction and control, no other computer anywhere near the price equals the RCA 110.

A solid state system utilizing circuits and components proved in thousands of hours of computer use, the RCA 110 offers capabilities that range from checkout and logging to complete real-time control of missiles in flight. *Without modification*, the Computer will exceed the requirements of most data reduction or control problems. Custom variations can be provided to fit any special job.

Here are a few highlights of the RCA 110's performance:

- Can operate on-line in missile ground control and checkout systems to address, monitor, analyze and control digital or analog signals at rates up to 3,000 signals per second.
- Computer speed and buffering are so well planned that the RCA 110 stays far ahead of input/output devices and signals in most data reduction, checkout and control applications. For example, memory cycle is 9.7 microseconds.
- Powerful automatic priority interrupt feature provides "first things first" control. During operation the RCA 110 checks each input/output device, notes calibration deviation, and adjusts the program accordingly.
- Complete self-checking routines inspect for proper performance at all times.

The RCA 110 is designed and built to operate at maximum efficiency under the most rugged conditions, and on the most complex real-time problems. Cost is less than any comparable electronic control computer available.

For detailed information and specifications, write Electronic Data Processing Division, RADIO CORPORATION OF AMERICA, 21 Strathmore Road, Natick, Mass.

COMPARE THESE PERFORMANCE SPECS

Speed—including access time and staticizing, adds in 56 microseconds, multiplies in 728, divides in 868. *Instructions*—one address (limited two address), 7 indexable address modifier registers, 71 wired-in instructions. *Number System*—fixed point, binary or binary coded decimal. 24 bit word length, word time 28.89 microseconds. *Working Storage*—magnetic core, coincident current, variable in size from 256 to 4096 words, 8 high-speed input-output registers, clock frequency 936 kilocycles. *Bulk Storage*—magnetic drum, 3600 rpm, 4096 to 160,000 or more words, 8.3 milliseconds average access time, 200 kilocycle transfer rate, up to 12 buffer tracks for input-output. *Size*—82" high, 34" deep, 105" long. *Typical Power Input*—5 kva, 220 volts.

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Jet engine checkout systems
Wind tunnel control and data reduction systems
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Automatic Abort for Mercury-Atlas

Astronaut safety system predicts catastrophic failures in Atlas booster and initiates abort sequence to separate capsule

NEW YORK—Safety of the *Mercury* astronaut during launch and boost will be guarded by a 36-lb. electronic system that can react 100 times faster than a human.

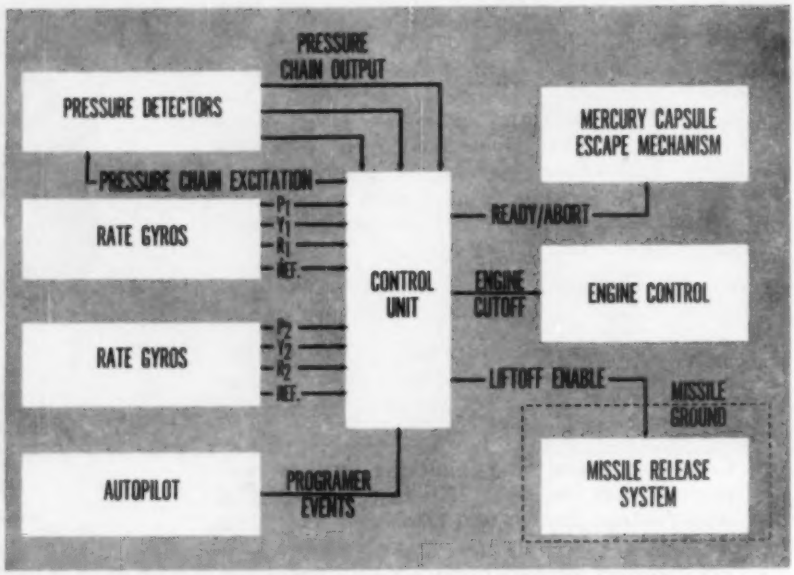
The system, called ASIS—for abort sensing and implementation—will sense and predict failures that might endanger the astronaut's life. When such a failure occurs, ASIS will initiate an abort sequence to separate the capsule from the missile and propel it safely away from a possible explosion.

First details of the system, developed by Convair Astronautics, were revealed in a paper presented here at the recent Institute of Radio Engineers Convention.

T. A. Heinsheimer, Convair engineer who presented the paper, said the ASIS was incorporated in the *Mercury-Atlas* so that no catastrophic failure of the missile could endanger the manned capsule. He said built-in redundancy and self-checks make the system itself as nearly failure-proof as can be designed.

Development of ASIS was based on data from *Atlas* flight tests, static firings and computer simulations which indicated that certain critical subsystems aboard the missile could be monitored to predict catastrophic failure. The interval between a subsystem malfunction and the resulting failure can be so short, however, that no human command decision to abort the mission can be made quickly enough; a fully automatic decision-making system must be used.

During flight, ASIS monitors performance of the propulsion, pneumatic, electrical, hydraulic, and flight control subsystems at critical points throughout the missile. The monitoring signals are continuously fed into the ASIS control unit mounted in the missile pod. This unit performs all necessary logical operations upon these signals and makes the abort decision. If all input signals are normal, the control unit indicates a "ready" condition. Should one or more of the monitored parameters deviate from pre-established limits, the control unit generates the "abort" command.



ASIS MONITORS all critical missile parameters to predict impending failures. If measurements go outside preset limits, it automatically initiates capsule escape.

ASIS is designed with a high degree of redundancy—both in the electrical circuitry and in the monitoring electro-mechanical sensors—so that it will not generate an abort command due to a failure in its own system. Such an inadvertent abort command would be indistinguishable from a legitimate command and would, therefore, initiate the capsule escape sequence. There must be no system failure which could cause an erroneous abort command to be sent, or prevent the system from operating properly in the event of an actual missile malfunction.

Components of high reliability and proven flight performance were selected for the system. Extensive failure mode analyses were conducted in order to select components whose failure (though unlikely), would be in a definite direction. In addition, suitable electrical and mechanical derating factors were applied to each component.

Each critical parameter is monitored by dual sensors—or transducers—whose outputs are channeled to the control unit.

Signals from the autopilot programer initiate the arming and disarming of several sensor signals as well as the arming and disarming of some of the ASIS functions. The system is armed by a signal from the programer at missile liftoff after which it can command capsule escape whenever warranted. At liftoff plus thirty seconds the programer arms the system's engine cut-off capability so that an abort command will automatically shut down the *Atlas* engines.

At staging—when the booster section is jettisoned and propulsion maintained by sustainer solo operation—transducers which monitor booster engine performance are no longer needed, and are therefore no longer observed by the control unit. At the same time, changes are made in some of the parameter threshold levels (the level a parameter must reach before an abort condition is present). In this way,

the control unit is kept informed of the progress of the flight and is able to properly evaluate missile performance at any time during flight.

The outputs of the control unit are the ready/abort signal to the *Mercury* capsule escape mechanism, the engine cutoff command, and the liftoff-enable signal. Liftoff-enable is sent while the missile is still on the ground. After main-stage ignition—while the missile is still held down by the launcher—all parameters monitored by the control unit reach their normal operating values, and the control unit goes into the "ready" condition.

At this time a liftoff-enable signal is sent through a missile umbilical to the missile release system. When this signal, and a number of others sent from other missile checkout systems, are all received by the release system, a signal is sent to the launcher and the missile is released. If the liftoff-enable signal is not sent by the control unit due to a fault in some area of missile performance, release will not occur and the engines will shut down automatically.

Parameters monitored by the control unit include a group of pressures which determine proper operation of the missile pneumatic, hydraulic, and propulsion systems: fuel injection pressures of the three engines, LOX tank pressure, the differential pressure across the main bulkhead, and the sustainer hydraulic pressure.

The outputs of two sets of rate gyros are used by the control unit to monitor performance of the missile stabilization and control system. Each set consists of three rate gyros to detect rotational rate about the pitch, yaw and roll axes. The final parameter monitored by the control unit is the missile a-c line voltage, sensed within the unit.

• **Rate sensing**—Each of the six rate gyros is monitored by an over-rate detector circuit. The output of this detector is zero as long as the gyro output is within safe limits. If, however, the gyro output becomes excessive, indicating excessive missile rotational rate, the output of the detector switches to seven volts. The detector is, in effect, an analog-to-digital converter which provides an output voltage only when an abort condition is to be indicated.

• **Pressure sensing**—Each pressure switch is wired in parallel to its redundant mate—an arrangement resulting from failure mode analyses made on the switches used. Each set of switches is then wired in series and the entire chain energized with a 35-volt signal stepped down from the 400 cps 115-volt missile power supply.

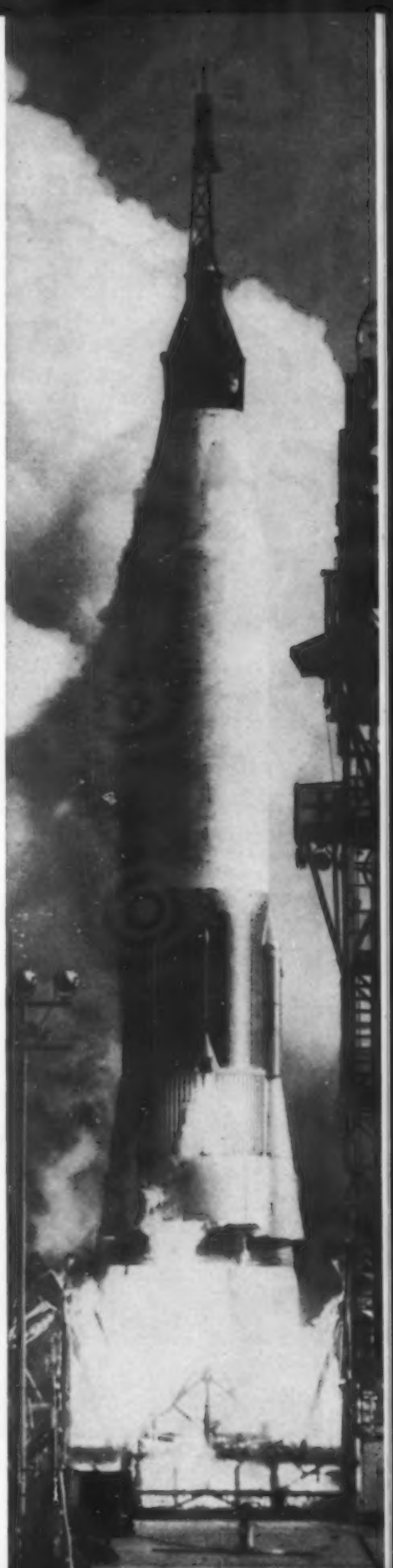
At staging, the closure of the booster cut-off relay contacts within the control unit short-circuits the fuel pressure switches in the two booster engines, thereby bypassing them in the chain. At the same time, a low-pressure LOX sensor is added to the chain in parallel to the LOX pressure switches already there. The addition of the LOX pressure switch compensates for the reduction in pressure required during sustainer solo operation.

Each switch remains in the shorted position as long as its excitation pressure is within acceptable limits. Each therefore, completes its link in the chain and, when all pressures are normal, 35 volts is seen by the pressure chain output transformer. The output of the transformer is rectified and then fed through Zener diodes into magamp one-not gates. When the pressure chain is broken by the opening of both switches of a pair, the input to the one-not gates falls to zero and the gates turn on.

• **Line voltage sensing**—Zener diodes are used in the pressurization sensing line to sense the level of the a-c power supply. If the line voltage drops, the 35 volts output of the pressure chain drops proportionately. When the rectified signal through the Zener diodes drops to below their Zener voltage the entire output of the pressure chain is effectively blocked by the diodes. The one-not gates, therefore, sense no input voltages and act as if the pressure chain had been broken by the loss of a monitored pressure.

• **Control unit output**—Outputs of the six over-rate detectors, and the two one-not gates are connected to a pair of two-not gates. The two-not gates are designed to stay in the "on" condition as long as the inputs to both control windings are effectively zero. Should a significant input current excite either of the gate's control windings it switches to the "off" position. An output from any of the eight logical circuits feeding into the two-not gates turns both gates off.

The drop-out of the two-not gate output voltage is the signal recognized by the capsule escape mechanism as the abort command. This drop-out of voltage also results in the de-energizing of the engine cutoff relays in the control unit. If more than 30 seconds have passed since missile liftoff, the engine cutoff capability of the ASIS is armed, and a 28-volt signal is sent to the engine control system to shut down the *Atlas* engines. ⁂



NO ASIS was needed in completely successful Mercury Atlas 2 shot Feb. 21.

Designing Data Display For Pilot of Spacecraft

by Charles Owen Hopkins
and
D. K. Bauerschmidt
Hughes Aircraft Company

SENSING, PROCESSING and display of the data astronauts must have in order to participate in guidance and control will make up a significant portion of the electronics aboard manned hypersonic vehicles.

The astronaut will need information on vehicle orientation, flight path, orbital parameters and environment—information which is reliable, easy to interpret, highly accurate, and presented with small weight and volume.

Unfortunately, the equipment—and in some cases, the basic techniques—necessary to attain this are not available. The difficult task of conceiving, developing, testing and evaluating the techniques and equipments is in the hands of the designers.

Recent studies indicate that the human operator's best contribution is in command or system management.

The astronaut's primary job will be to determine the state of the system and evaluate it in relation to the planned mission requirements and the various alternative programs provided. When he has done this, he will designate alternate subsytem operations and/or alternate basic system programs to be carried out.

• **Evaluating the system**—First, the pilot senses the information. His primary sources are visual and, to a considerably lesser degree, auditory displays of already processed information. The auditory displays mostly involve communications and system malfunction warnings, although this information may also be displayed visually.

In some instances, information about the state of the system may be sensed directly. The pilot may "feel" the vehicle's condition by his own sense of balance or muscular movements. Or he may determine the vehicle's path by looking through viewports and periscopic devices.

Secondly, the human operator must assimilate sensed information with previously acquired information—a function for which the human is uniquely qualified and may be far superior to any machine. He can then predict the probability of success of the current program.

His next function may be to designate an alternate mode of operation for a subsystem, or an alternate basic system program for a subsequent mission phase. If necessary, he may designate an alternate program that will terminate the planned mission but result in recovery of the system.

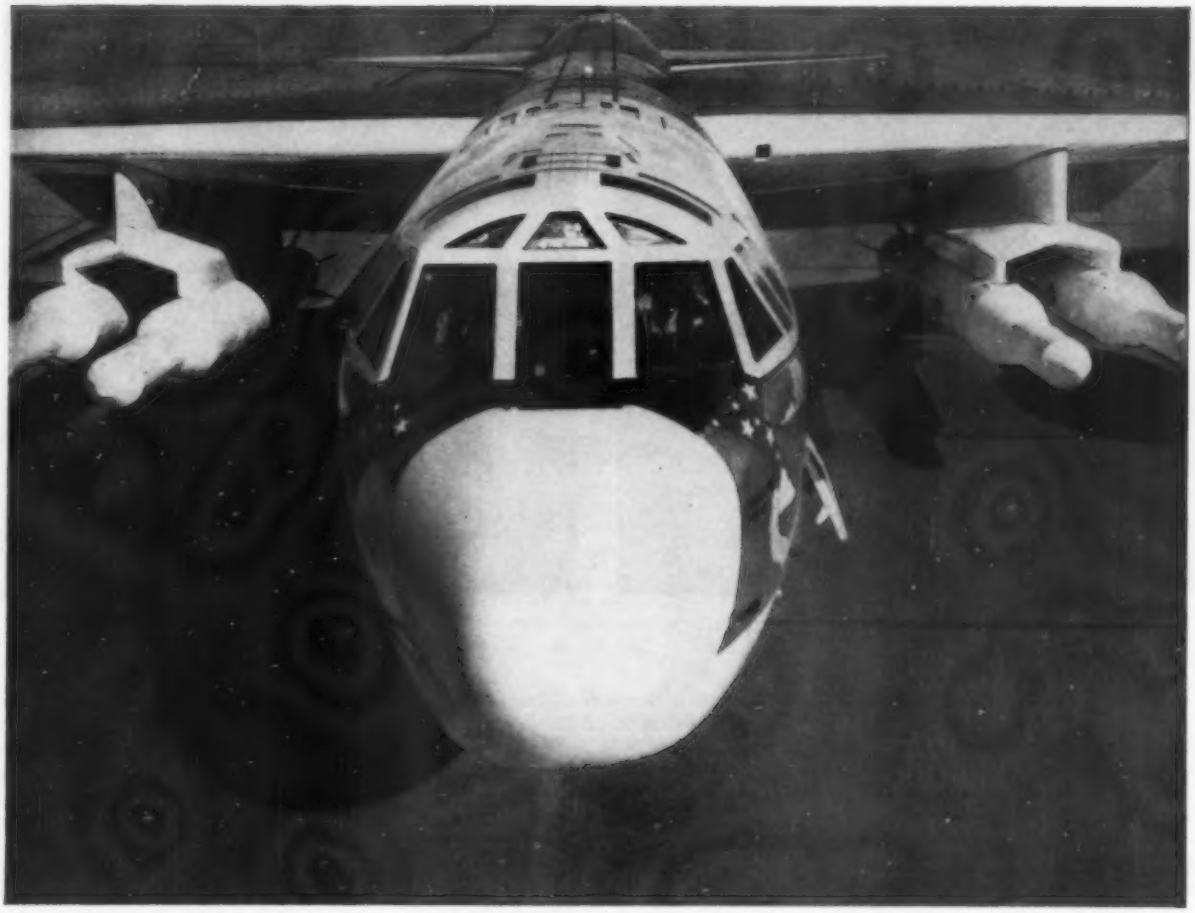
• **Other jobs**—Although these tasks will constitute his most important responsibility, the pilot may be given additional assignments. These may include manual operation of auxiliary sensing devices, transmission of manually acquired information to the system, requesting certain information from the system, and—to a limited degree—processing manually acquired data by means of charts, graphs, tables and perhaps a special-purpose hand-operated computer.

Under very special conditions, the human operator may be required to function as a continuous controller of vehicle output, regulating vehicle attitude and thrust. This would most likely occur during the final closing maneuver of a rendezvous mission phase or as an emergency backup mode of operation.

• **Kinds of information**—Categories of information the human operator will need are:

—Current system-mission status: vehicle flight path, vehicle attitude, and subsystem and component status. These subclasses of information may be further subdivided; for instance, flight path information may be either orbital flight path information or atmospheric flight path information, depending upon the mission phase. Orbital flight information may be either earth-referenced for near-earth orbits or target-satellite-referenced during part of the rendez-

Figure 1. Orbital Situation Display



MISSILE BOMBER. New "H" model is latest version of famous Boeing B-52 missile bomber, most versatile long-range weapon system in U.S. Air Force arsenal. B-52H here carries mock-ups of four Skybolt air-launch ballistic missiles. B-52s can also carry supersonic Hound Dog missiles for in-flight launching toward distant targets. Flying high or low, B-52s will provide an almost undetectable launch pad for missiles. They can also carry regular load of gravity bombs, and strike up to five targets on single mission.

Capability has many faces at Boeing

RESEARCH STATION. Model of space research station designed by Boeing to accommodate12 men and remain in earth orbit, serving as research station or interplanetary launch site.

SPACE CHAMBER. Boeing multi-stress chamber simulates six conditions of space travel in research to develop protective environments required for space vehicle crews. Chamber will also be used to test conditions in moon stations.

"FLYING" BOAT. Drawing of 115-foot hydrofoil craft Boeing is building for U.S. Navy. Riding out of water, hydrofoil will "fly" on underwater wings at speeds up to 45 knots. Powered by two 3000-hp gas turbine engines, craft will be the biggest hydrofoil ever built.

BOEING

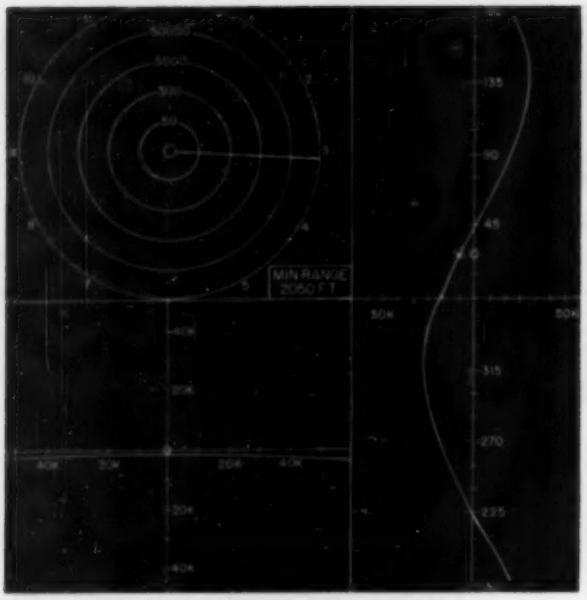


Figure 2: Transfer Display

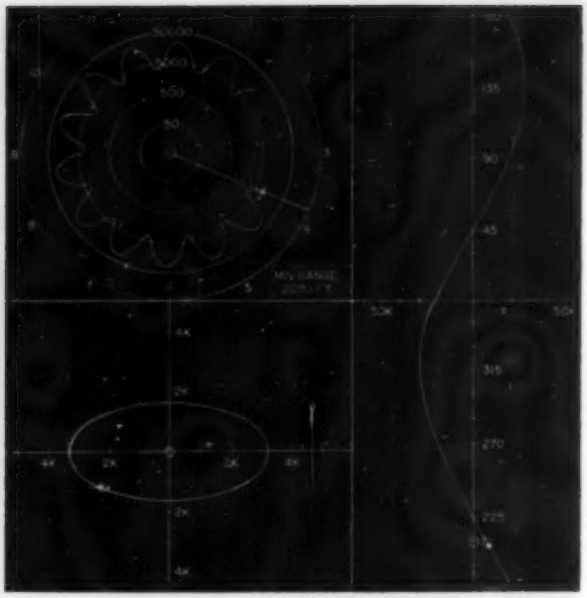


Figure 3: Rendezvous Display

vous phase of a ferry vehicle mission.

—Requirement or command: time of next thrust application, the required velocity increment (ΔV) for next maneuver, command attitude angles and rates, etc.

—System capability: available energy in various forms and remaining supply of life-support stores. Life support becomes important since its capability may influence alternate modes of operation or alternate mission programs.

• **A specific case**—Each mission, each system, will have its own information requirements. Here is an example of how Hughes Aircraft Co. designed displays to meet a set of specific requirements:

The mission may be summarized as follows: The vehicle is launched from the earth and injected into a circular polar orbit at an altitude of approximately 450 miles. This is followed by a minimum energy transfer to effect a rendezvous with a target satellite in a coplanar orbit at an altitude of 500 miles. After making soft contact with the target satellite and transferring stores and/or personnel, the vehicle departs from orbit at the appropriate time, safely re-enters the earth's atmosphere and glides to a landing at a designated base.

The major mission requirements are (1) initiation of powered flight, (2) attainment of a planned orbit, (3) rendezvous with a target satellite, (4) departure from orbit, (5) attainment of aerodynamic flight, (6) arrival in the vicinity of the landing base, and (7) controlled landing at the base.

This example will concern itself with steps 1) through 3), beginning with cutoff or burnout of the injection-stage rocket motor.

System requirements for this mission phase are (1) stabilization of vehicle attitude, (2) initiation of appropriate vehicle pitch rate, (3) determination of orbital elements and related parameters, (4) minor rotation of the plane of the orbit, and (5) transfer to the target satellite orbit. The system functions, automatic or manual, which must be performed are summarized in Table I.

In the interest of brevity, requirements and functions will not be discussed in detail.

Specific information required by the human operator is presented in Table II.

• **Three sources**—Hughes has proposed three displays (Orbital Situation Display, Transfer Display, and Rendezvous Display), intended to provide the operator with both quantitative and pictorial information needed for orbit adjustment and transfer.

Before a transfer orbit is initiated, the primary orbital flight path information to be displayed to the operator is referenced to the earth (Fig. 1). This display presents in a pictorial manner, by means of cathode-ray traces on a 12 x 12 in. viewing screen, the size and shape of the target-satellite and the ferry-vehicle orbits, as well as the instantaneous positions of each vehicle in its respective orbit and predicted positions of future thrust applications. Orbital parameters for both the ferry vehicle and the target satellite are presented quantitatively by means of a column of alpha-numeric readouts along the right-hand edge of the display.

The pictorial presentation shows the orbital paths of both the ferry vehicle and target satellite against a background of fixed display elements representing the earth, the limit of effective atmosphere, and altitude increments above the earth's surface. The earth is represented by a ½-in.-diameter circle in the center of the pictorial display area. The altitude scale consists of concentric rings labeled 1 through 5 representing altitude at 100-mile intervals up to 500 miles. The limit of the effective atmosphere, based upon an assumed atmospheric model, is shown by a fuzzy circle at approximately 60 miles altitude.

The orbital paths of both the ferry vehicle and target satellite are presented against the fixed altitude rings by cathode-ray traces. Instantaneous position of the ferry vehicle in its orbit is shown by a small filled circle with an arrow pointing in the direction of travel in the orbit. A small open circle indicates the instantaneous position of the target satellite.

A small x indicates the point in the ferry vehicle's orbit where the next thrust application is to be made—in this case, for initiating a transfer orbit. Emanating from the x is a color-coded arc representing the transfer orbital path predicted to result from the application of thrust. The transfer orbital path arc terminates at the predicted point of interception of the target satellite. This is shown by a short bar intersecting the target orbit trace at a right angle. This point is the apogee of the transfer orbit, where a thrust application must be made to attain circular

TABLE I. System Requirements and System Functions During Rendezvous Phase

SYSTEM REQUIREMENTS	SYSTEM FUNCTIONS
Stabilize Attitude	Sense vehicle attitude conditions. Determine corrective attitude jet thrust. Apply corrective thrust.
Initiate Pitch Rate	Determine correct pitch rate. Determine required thrust. Apply thrust to initiate pitch rate.
Determine Orbital Elements	Determine orbital elements or related parameters. a. Size and shape of orbit. b. Position of vehicle in orbit. c. Orientation of orbit in space.
Rotate Orbit Plane	Determine time of arrival at node. Determine amount and direction of required thrust. Apply thrust to rotate plane of orbit. Repeat attitude of stabilization if necessary.
Transfer to Destination Satellite Orbit	Determine critical central angle between satellites. Determine time of occurrence of critical central angle. Determine required thrust magnitude. Apply thrust to initiate transfer ellipse. Repeat attitude stabilization, if necessary. Determine arrival time at apogee of transfer ellipse. Apply thrust at apogee to achieve circular velocity. Repeat attitude stabilization, if necessary.

orbital velocity at the target satellite's altitude.

The quantitative information display has been arranged so that readouts of closely related information are grouped together. At the top of the column and enclosed within a square are three readouts of information concerning the height of the ferry vehicle's orbital path over the earth. These are labeled APOGEE, ALTITUDE, and PERIGEE—indicating the altitudes to the nearest 1/100 nautical mile of the apogee of the orbit, the instantaneous altitude of the vehicle and the perigee of the orbit, respectively.

Immediately beneath the square enclosing the altitude information are four readouts presenting information about size and shape of the orbit, the orbital period, and the position of the ferry vehicle in the orbit. Orbital size and shape are presented by the readouts labeled SEMI-MAJ AXIS, which indicates the length of the semi-major axis of the orbit to the nearest 1/100 mile, and ECCENTRICITY, which presents the orbital eccentricity to six decimal places. The ORBITAL PERIOD readout presents the time required to complete one orbit to the nearest 1/100 minute. Instantaneous position of the vehicle in its orbit as given by the central angle measured in the direction of vehicle movement from the ascending node is presented to the nearest 1/10 degree by the CENTRAL ANGLE readout.

Next in the readout column is a set of four readouts, enclosed by a square, displaying the orientation of the orbital planes of the ferry vehicle and the target satellite. The readouts indicate the angles of inclination and the right ascension of both the ferry vehicle and the target satellite to the nearest 1/100 degree. Following these indications, the angle between the ascending node and perigee measured in the direction of vehicle travel in orbit is indicated by the ARGUMENT OF PERIGEE readout to the nearest 1/100 degree.

The two readouts in the next square present information on angular relationships between two satellites. The current central angle between the ferry vehicle and the target satellite, measured from the ferry vehicle in the direction of travel in the orbit, is presented to the nearest 1/100 degree. So is the value of the central angle between vehicles at which thrust must be applied by the ferry vehicle in order to initiate a minimum-energy transfer ellipse to intercept the target satellite.

The readout labeled HOHMANN FLIGHT TIME, located at the bottom of the column, presents to the nearest 1/100 minute the predicted time required to complete the transfer orbit (Hohmann orbit).

After the ferry vehicle is in the transfer orbit the flight path information of primary interest is that shown relative to the target satellite. The transfer display shown in Fig. 2 presents this type of information.

The reference system used for specifying the position of the ferry vehicle relative to the satellite is a moving Cartesian coordinate system with its origin at the center of the target satellite. The y-axis is directed along the target satellite's radius vector. The x-axis is normal to the radius vector in the plane of the orbit; the z-axis is normal to the plane of the orbit. The position of the target satellite in its orbit is specified in degree of central angle (η), measured from the ascending node in the direction of satellite travel.

The Transfer display has been divided into three parts in order to show clearly on a two-dimensional display surface the relationship between the satellites in the three-dimensional space defined by the coordinate system.

A rectangular area located in the lower left part of the display shows the predicted path of the ferry vehicle, relative to the target satellite, projected onto the plane of the satellite orbit. Because the fixed display elements include an intersecting horizontal and vertical line representing the x- and y-axes of the coordinate system, this part of the display is called the x-y presentation. A small circle at the origin represents the target satellite. The index marks represent distance increments of 10,000 feet along the axes.

The predicted path of the ferry vehicle relative to the target satellite, as computed from the orbital elements of both the ferry vehicle and the target satellite, is shown by a cathode-ray trace against the fixed reference axes. Apogee of the ferry vehicle transfer orbit, which is also in this case the predicted point of thrust application for the establishment of circular orbital velocity at the altitude of the target satellite, is shown by means of a short bar intersecting the predicted path at a right angle. If the instantaneous position of the ferry vehicle is located within the portion of the orbital path shown, it is represented by a small filled circle with an arrow pointing roughly in the direction of vehicle motion.

A Z-η presentation occupies a rectangular area 4 in. wide and 10 in. high at the right side of the display. The vertical line represents the plane of the target satellite orbit, and the horizontal line represents the earth's equatorial plane. The intersection of these lines represents the ascending mode of the target satellite orbit. The scale on the vertical axis represents central angle in degrees measured from the ascending mode in the direction of satellite travel. The index marks on the horizontal axis represent distance increments of 10,000 feet from the plane of the orbit in a direction normal to the orbit (z-scale).

The instantaneous position of the target satellite in its orbit is shown by a small circle that moves along the vertical line. The predicted path of the ferry vehicle for one complete orbit is shown in terms of its deviation from the destination satellite orbit by means of a cathode ray trace. If the ferry vehicle transfer orbit and the target satellite

TABLE II. Specific Information Required by Operator During Rendezvous Phase

GENERAL SYSTEM REQUIREMENTS	CATEGORY OF INFORMATION		
	SYSTEM-MISSION STATUS	REQUIRED OR COMMANDED	CAPABILITY
Attitude Stabilization	Pitch, roll and yaw angles and rates. Status of stable platform, auxiliary sensors, computer, etc.	Pitch, roll, and yaw angles and rates.	Amount of attitude control system propellants remaining.
Orbit Adjustment	Burnout conditions (h, V, vpa, time). Computed orbital elements and related parameters. Pictorial orbital relationships (referenced to earth). Instantaneous position over earth (pictorial and Lat.-Long. readouts.) Time remaining to next thrust.	Desired size and shape of orbit and acceptable variations. Magnitude, direction and time of application of next thrust.	Main rocket engine propellants: 1. Amount remaining. 2. Amount required for next thrust. 3. Amount required for safe de-orbit after next programed thrust. 4. Reserve.
Orbit Transfer	Computed orbital elements and related parameters for vehicle and target satellite. Pictorial orbital relationships (referenced to target satellite). Range to target satellite (radar or optical). Collision warning. Time remaining to next thrust.	Critical central angle for starting transfer ellipse. Magnitude, direction, and time of application of next thrust.	Main rocket engine propellants: (same as in cell above). Predicted transfer orbit. Predicted range to target satellite. (Minimum range and variation of range with time.)

orbit were coplanar, the trace showing the predicted path of the ferry would be coincident with the vertical line on the display. For orbital plane differences causing deviations within the z-scale on the display, the ferry's predicted path trace will be a sinusoid varying about the y-axis, as shown in Fig. 2. The instantaneous position of the ferry vehicle relative to the target satellite is shown on the predicted path trace by a small filled circle with an arrow pointing in the direction of vehicle travel.

The third part of the Transfer Display, an R-T presentation in the upper left corner, shows predicted ferry-vehicle to target-satellite range variations as a function of time for the next 10 hours. The fixed display references are six concentric circles. The outermost circle contains 48 equally spaced index marks representing 15-minute increments of time. The index marks at the conventional positions are labeled 1 through 12. The innermost circle represents the target satellite. The remaining four circles represent ranges from the target satellite in feet on a logarithmic scale.

Present time is shown by the position, relative to the clock markings, of the end of a cathode-ray trace that appears as a radial line. The predicted range variation as a function of time for the next 10 hours is shown by a cathode-ray trace emanating from the radial line. Instantaneous range to the target satellite is indicated by the position relative to the fixed range circles of a filled circle with an arrow located on the radial line. A numerical readout of the predicted minimum range for the given time period is located in the lower right hand corner of the R-T presentation.

During the terminal part of the orbit transfer it is desirable to display predicted ferry vehicle orbital path information with greater precision. Therefore, the display scale factor on the x-y presentation is changed to 2000 feet to the inch as compared to the scale factor of 10,000 feet to the inch on the Transfer Display. The display with the greater sensitivity is then referred to as the Rendezvous Display.

A typical rendezvous situation as it might be displayed on the Rendezvous Display is shown in Fig. 3. The orbit transfer has been completed by means of the second thrust application, but a closing maneuver has not been made. Present range to the target satellite is about 6000 feet. The orbital elements of the two satellites are not matched exactly but their orbital periods are approximately equal. ¤

Calco Pump Vital to Titan's Guidance

DEEP WITHIN the *Titan* guidance system is a small but critical immersible pump motor developed for the A. C. Spark Plug system by Calco Manufacturing Co., Addison, Ill.

Calco was asked to design and manufacture a motor capable of delivering 2500 hours of continuous duty. The watt input and power factor were considered critical because other sources in the system were programed for explicit usage. The power source was to be 115V. a-c, single phase.

The pump motor was to pump a fluorochemical through the gimbal at a given flow and pressure, while completely immersed. The continuous duty motor temperature rise was to be less than 40°F.

All components receive 100% inspection under a 30 power microscope, and are then cleaned in an ultrasonic cleaner with Freon 113. No components, once cleaned, are handled without the use of decontaminated gloves.

Special test equipment was procured to satisfy exacting performance requirements. Readings of power frequency and watt input were made within 0.05% accuracy.

With a special end bell, diffuser plate and impeller, the pump motor was found to give maximum performance.

A motor fully meeting design requirements was furnished in just 90 days. It was selected as the result of 28 prototypes, covering six engineering designs. This final version has a power source of 8.4V. a-c, two phase, instead of the 115V. a-c, single phase originally planned, plus the lowest watt input possible to achieve.

Life tests duplicating actual service conditions show to date a continuous run of 24 hrs. a day, 7 days a week, for a total of 10,000 accumulated hours—with an expectancy of 15,000 hours, a performance far superior to the original requirement.

A. C. Spark Plug engineers have reported that checks made every 200 hours, after 10,000 hours of life, show no dimensional wear. ¤

He solved this puzzle by taking it apart!

Like oil and water, extreme precision and "complete" mobility resist combination in tracking radar antennas. Designing for one of these characteristics "automatically" precludes the other. *That* was this AMF Engineer's puzzle – to put *both* precision *and* mobility in an antenna for duty with the Marine Corps.

He solved the puzzle, literally, by taking apart the solution – AMF's TPQ-10 antenna – into 10 rugged, portable, submersible, precision-fabricated packages. TPQ-10 is designed for helicopter transport. Each component can be dropped in water; it will come up for more. The packaged antenna on its pallet can be dropped on land from 3 feet without impairing precision.

Each component can be *picked* up – the largest weighs 425 lbs. – and can be handled by 3 men. A crew of 6 can put TPQ-10 together in 20 minutes with one standard wrench.

Among the design innovations that solved the puzzle is a "piggyback" gear arrangement that puts both azimuth and elevation drives in one package. Result: almost half the parts and weight of separate components. Precision fabrication is typified by the reflector arms, held to a .005" deviation over 45 inches!

(For unclassified information on early warning and radar antenna systems, write Dept. CS 1, address below.)

Single Command Concept

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U.S. Charts Surface of Moon

Geological survey's mapping for NASA and Army Engineers is described at joint meeting of ASP and ACSM in Washington

by Charles D. LaFond

THE LUNAR SURFACE is being given continuous study as a prelude to man's exploration of earth's only natural satellite.

The U.S. Geological Survey (USGS), Department of the Interior, is performing the study for the National Aeronautics and Space Administration and the Army Corps of Engineers. Through comprehensive photogeologic interpretation, it is applying its findings to 1:1,000,000 scale base maps compiled by the Air Force.

The photographs with which much of the USGS activities are concerned are stereo pairs. These are obtained not with widely spaced cameras, as would be expected, but by proper orientation of photographs taken at lunar libration extremes. Even with cameras on opposite sides of the earth, the angular difference would only be about 1.75°. This is insufficient for good stereo viewing.

However, the moon experiences up to a 13° total latitudinal libration and 16° total longitudinal libration over a period of time. Thus, photographs of the moon made at two librations having an angular difference in view of 15° are comparable to those which might be taken from two points in space some 75,000 miles apart. For stereo-photo interpretation, this apparent base line is sufficient to provide the necessary depth.

These details of advanced lunar mapping techniques were presented by Robert J. Hackman, USGS, in one of many papers related to this year's ASP-ACSM conference theme of "Space Mapping."

Over 80 exhibits and scores of papers were offered in this annual joint week-long meeting in Washington at the Shoreham Hotel of the American Society of Photogrammetry (ASP) and the American Congress on Surveying and Mapping (ACSM).

To orient photos, said Hackman, the geometric center of the lunar disc in each pair of photos must be determined, the conjugate image point of each center is located on the complement image, conjugate and geometric centers on each photo are then aligned with the x-direction of the stereo viewer, and finally the pictures are separated for stereo effect.

Lunar stereoscopic models, Hackman admitted, are not geometrically correct because of the small base-distance ratio of the photo pairs. Nevertheless, with photos of maximum libration relief over 1000 feet are discernible. Features down to 100 or 200 feet are obtainable from shadows resulting from very low sun—such as the wrinkle ridges in the maria.

Even with the poor resolution of the photographs and telescopes employed, said Hackman, results of the lunar photointerpretation program are providing a broad framework for use in the future. When photo-reconnaissance rockets obtain more detailed pictures, the geologic maps can be more highly refined.

• **French project**—Another paper by Robert W. Carder described a comprehensive lunar photography program being carried out at Pic-du-Midi Observatory. Located in the Pyrennes Mountains in southern France, the observatory is systematically cine-photographing the entire visible portion of the moon on 9-in. aerial film. These will be used to support construction of 1:1,000,000 Scale Lunar Charts.

Techniques for determining heights of lunar features by shadow measurements, said Carder, have been refined by Professor Zdenck Kopal, University of Manchester, England. Charts have been prepared with 300-meter contours in localized areas with a probable error of 100 meters.

(Carder has directed the Lunar Charting Program of the Aeronautical Chart and Information Center, in St. Louis, for the past year.)

• **Stereo illusions**—Aerial photographic pairs obtained at hypersonic speeds and viewed stereoptically can show surface discontinuities as high as 50 feet where none exist. This and other environmental effects of supersonic and hypersonic speeds on aerial photography were described by J. N. Nielson and F. K. Goodwin of Vidya, Inc. a division of Itek Corporation in Palo Alto, Calif. The division is studying the problem for the Army Engineers' Geodesy Intelligence and Mapping Research and Development Agency (GIMRADA).

Many of the effects of boundary layer and shock waves on the metric distortions introduced into mapping photography, as well as the metric distortion caused by aerodynamic heating of the camera window, were described by the authors. Turbulent boundary layers, which occur in supersonic flight over a wide altitude range, can cause serious reductions in the resolution of photographs taken through these layers, they asserted.

The authors also described other degrading effects on photography occurring during very-high-speed flight, such as loss of contrast between the ground object and its background by the presence of luminous air in the associated flow field.

• **Survey accuracy cited**—The techniques for achieving super accuracy in surveying the supporting ballistic missile camera sites at Cape Canaveral were described by Commander Glenn W. Moore, U.S. Coast and Geodetic Survey.

The Azusa Model 2 tracking and impact prediction complex there employs several short orientation lines measured to an accuracy of 1 part in 400,000. Since the camera system was partly for use in testing and backup for the Azusa, Moore said, at least equivalent accuracy was mandatory.

However, the USC&GS wrote the requirements for the survey team calling for a precision equal to four times first order, or double the first-order accuracy.

Through a network of quadrilaterals with two diagonals, instead of single triangles, triangulation observations were made on at least each of two nights.

Measurements were performed with a Geodimeter. Combined with spirit leveling and 15 astronomic latitudes and longtitude, by astro-geodetic leveling, the relation between the geoid and spheroid at camera sites were obtained within 2 or 3 feet.

Final results of the survey produced an accuracy of better than 1 part in 1 million, according to Moore.

Use of the Perceptron (that class or family of "intelligent" machines employing the neural net for perceiving and recognizing automata) in experiments relating to photointerpretation was presented by Albert G. Murray of Cornell Aeronautical Laboratory, Inc.

As a result of tests in multiple and single recognition of characters mixed with other simple characters, it is believed that the use of such machines for scanning aerial photos was proved. Much work is needed, but while the lab Perceptron units showed a high rate of false alarm (recognizing unwanted character forms), detection rates for all tests approached 1.0 consistently, Murray said.

It was stressed by the author that Cornell's Mark I Perceptron, used in the tests, was not designed for specific tasks such as photointerpretation. Its sensory apparatus severely limits ground resolution and has no gray scale. Because of this actual aerial photos were not used, but merely approximated.

For the future, the lab will employ machines designed specifically for photointerpretation.

Automatic computation, processing, coordination, etc., in the fields of photogrammetry and cartography were given a fine scanning by Herbert P. Grossman, Concord Control, Inc. He particularly looked at the problem of accuracy vs. cost, indicating that the whole error problem must be faced with a frontal assault.

Yet costs rise staggeringly with each improvement and this fact must be considered by those demanding higher accuracies.

As error sources, he listed random, systematic, dynamic errors as those whereof designers must be fully aware. With study these can be compensated for. However, environmental effects, particularly temperature and humidity, are equally severe in mapping applications.

For these, he said, it is much better to control the environment rather than attempt compensation for changes as they occur.

Finally, Grossman said, if costs are to be heeded and if high accuracy is really the goal in an automatic machine, all other specifications must be relegated to a secondary role.

• **Stereomat pays off**—Winner of the Photogrammetric Award for 1960, donated by Fairchild Camera & Instrument Corp., was Gilbert L. Hobrough. Associated with Hunting Survey Corporation, Ltd., Toronto, Canada, Hobrough was cited for his development of the Stereomat, an automatic stereo plotting system (first reported by M/R, Oct. 24, 1960, p. 20).

The exhibits (over 80) were highlighted by a 3-dimensional model of the SECOR (Sequential Collation of Range). This is the Army Map Service's geodetic satellite program for long-range mapping of the Earth's continents.

Another item drawing wide interest was the Air Force's new Automatic Uniscale Matcher, developed by Autometric Corporation. Essentially a computer, it automatically measures scale distance between centers of PPI radar photos made with the same range setting and containing overlapping terrain detail.

The equipment compares four photos at a time and translates picture data to obtain a coincidence of common information. Output is visual and on punched cards. One complete photomatch requires 30 seconds.

Photogrammetry, Inc., showed its new Zenith Camera System which consists of a Zenith camera and a control unit. Developed for the Air Force, the control unit contains a radio receiver for WWV and WWVH time signals, a dual track tape recorder, batteries, and the camera controls.

The camera is a ground operated instrument designed to obtain photographs of stars at night in the vicinity of the zenith so that subsequent data reduction can be performed to compute the latitude and longitude of the camera station.

This system will allow rapid recording of accurate survey data where requirements, time, or conditions preclude more extensive field survey operations, said P.I.

The control unit is electrically cabled to the camera. Aside from inserting the photographic plate or film and the leveling of the camera, the operation is monitored in total from the control unit. This provides a two-channel tape recording of pertinent time information during exposure of photographic plate.

A continuous signal generated from an oscillator independent of the WWV receiver, provides an accurate record of the shutter opening and closing and the duration of the shutter opening, on one channel of the tape. Concurrent with this, WWV and WWVH time signals are recorded on a second channel for direct correlation with the shutter operation. Two exposures are made on the same plate, 180° out of phase with each other.

Star images can be precisely measured from processed plates in a comparator type instrument. The signals can then be visually read and measured to within 1/50 of an inch for an accurate interpolation, from specially processed magnetic tape.

• **Lorac at AMR**—A feature of an exhibit by Seiscor Division of Seismograph Service Corporation was its Lorac (Long Range Accuracy) system's use at the Atlantic Missile Range.

Employing phase-comparison radiolocation techniques for very accurate distance measurements, the system is installed on tracking and missile-launching ships and on several of the downrange islands.

Used first at AMR in 1952 for position control in a depth-charting survey prior to laying the range telemetering cable (and also during its installation), Lorac was later installed in a network in 1958 to support missile-launching vessels and for missile guidance system evaluation.

For optical and radar tracking shore stations, Lorac-B instrumentation is carried on the launch ships and submarines. Exact position (accuracy better than 1 part in 100,000) of each vessel is transmitted to shore sites for tracking orientation before launchings.

Similar data are provided in the impact areas for computer use to provide acquisition information needed to intercept the trajectory of a warhead and for flight-path evaluation. Position information, Seiscor said, can be transformed readily into true velocity, distance, range, and bearing as needed.

In using the principle of radio signal phase comparison, the Lorac system establishes a gridwork of hyperbolic lines of position. Medium frequency continuous-wave or modulated type transmitters with power capabilities up to 1500 watts are employed. Three or four stations may be used in a Lorac net to perform the trilateration. ⌗

Servonics Wins Navy Award For Track-While-Scan

THE NAVY has awarded a contract to Servonics, Inc. for an automatic track-while-scan radar system. The TWS system (M/R, Jan. 23) makes it possible to add multiple-target tracking capability to any scanning radar with little modification of existing equipment. Servonics says the development is a significant advancement in radar data collection, processing, and display. *(Ed. note: The Marine Corps is also reported to be contemplating purchase of the TWS for modification of present search radars.)* ⌗

For limited war . . .

Joint Chiefs Map Possible Merger of TAC and STRAC

DEFENSE SECRETARY Robert McNamara has ordered the joint chiefs to prepare a plan which might lead to the merger of the Air Force TAC fighter and air transport fleets and STRAC, Army paratrooper and reserve infantry units.

The move, predicted in COUNTDOWN (M/R, Mar. 27, p. 13), is one of more than 100 analyses of problem areas of U.S. defenses ordered by the new Secretary.

The plan would hand the Army more capability for handling "limited wars," by giving combat forces the control and direction of close air support for ground operations. Pentagon sources predict that the new unit will report directly to the Joint Chiefs of Staff, not Army or Air Force.

TAC has 46,000 officers and men, embracing the 9th Air Force, the 12th Air Force, the 19th Air Force and 10 other air bases in the United States. Its inventory includes fighter-bombers, tactical-reconnaissance aircraft, long-range heavy cargo and assault troop-carrier aircraft, and *Mace* and *Matador* missiles. STRAC has 55,000 officers and men, including the Army's crack paratroop division. Although designed as a four-division combat force, it has been reduced to three by periodic reductions in Army strength.

Some preliminary studies on the merger of TAC and STRAC were conducted by military leaders in the Eisenhower Administration. Gen. Lyman Lemnitzer, then Army chief of staff, worked with Gen. Thomas D. White, Air Force chief of staff, to determine requirement and means for such a merger.

McNamara has given Joint Chiefs Chairman Lemnitzer until May to draft a plan. ¤

French Outline Varied Five-year Space Program

by Jean-Marie Riche

FRANCE has earmarked $2.6 million for a unilateral space program for the next five years.

Besides cooperation in the European space program, France is embarking on its own program to be worked out by the National Center for Study of Telecommunications, Paris University's Research Laboratory of the Atmosphere, Research Center on Cosmic Rays and National Meteorological Department.

The program includes an observation of Venus by astronomer A. Dollfuss from a high-altitude (80,000 ft.) point where he will be taken by a "grape" of 30 balloons.

During 1961, the program will include a survey of solar phenomena (cinematographic survey of the Sun, spectrography of the solar ring, observation from the Meudon Observatory), the observation of artificial satellites and the calculation of orbits (by 24 stations), research on ionosphere, exosphere, the high and low atmosphere, radio electric research on satellites, experiments conducted with rockets, experiments in the fields of astrophysics using polyethylene balloons and research on cosmic rays.

A number of sounding rockets will be launched in the atmosphere by high-altitude probes, some of them from the Kerguellen islands and new research stations to be established on the South Pole, Central Africa and in France.

In the next five years France will launch *Belier* and *Centaure* rockets from its Saharian base at Hammaguir.

France has also pledged its cooperation to the European Space Research program. ¤

Joint Program

U.S., French Reveal Plans for Launchings

SPACE OFFICIALS of the United States and France have agreed on the first steps in a joint effort in which U.S. rockets and satellites will be used for launching French experiments.

The agreement grew out of joint talks in Washington March 20-21 between officials of the French Committee for Space Research and the National Aeronautics and Space Administration. In a "memorandum of understanding" issued last week, the two groups said there would be these first steps:

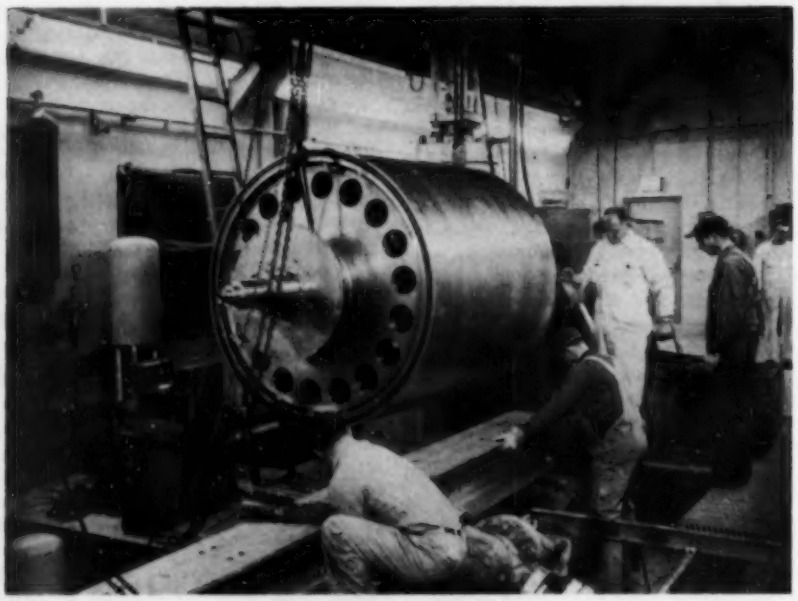
—The French will put together ionospheric, biological and upper-atmospheric experiments for which NASA will provide sounding rockets. The biological experiments would involve no living animals, but spores and molds.

If the results of these shots are satisfactory, the French will prepare similar experiments for incorporation in NASA satellites.

—The French and Americans will cooperate in designing, equipping and operating a launching site for sounding rockets at Quiberon, on the South coast of Brittany, in France.

—NASA will make its training facilities available for French personnel.

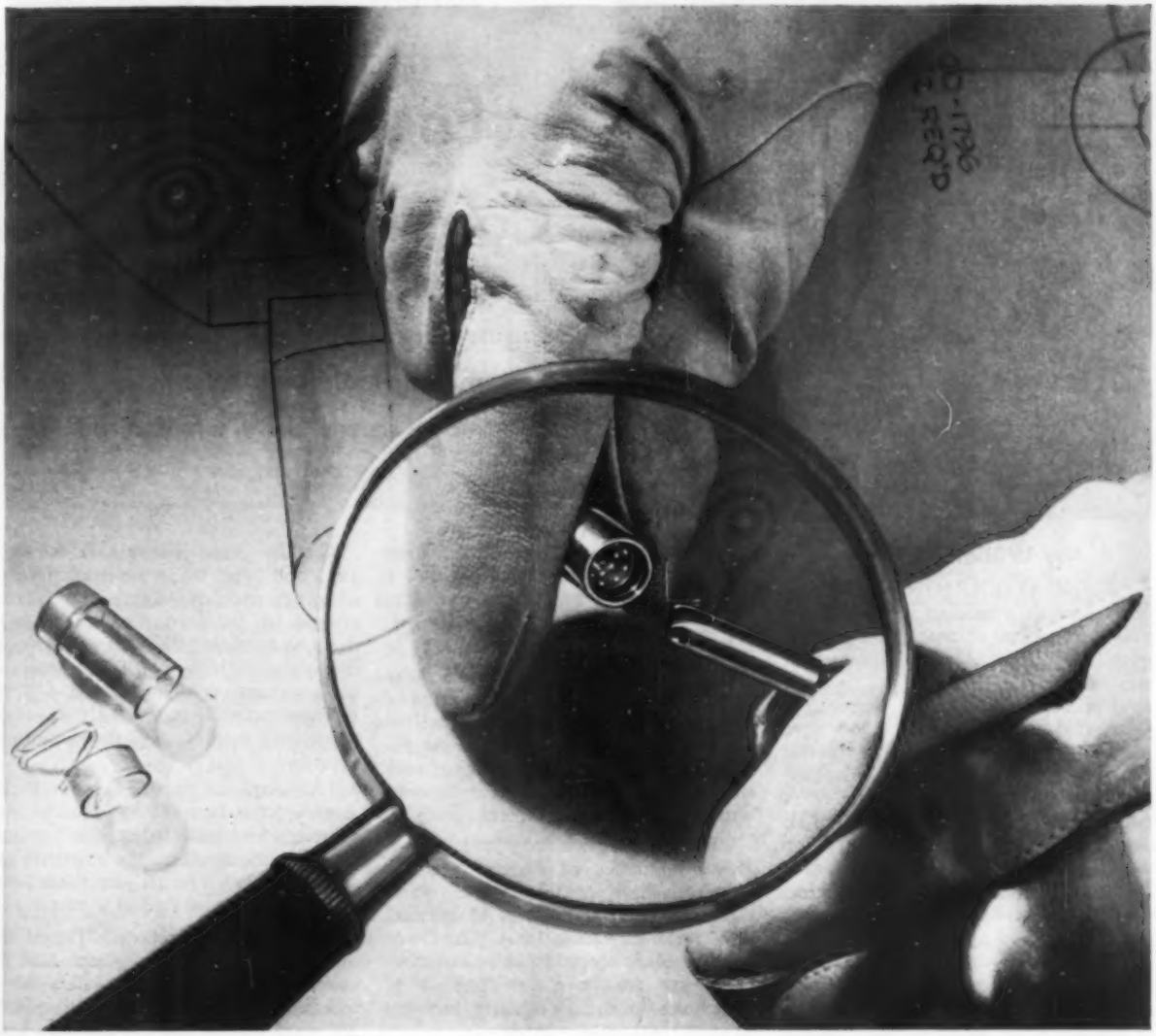
The memorandum made it clear that there would be further cooperation. ¤



Heavy Wheeling Tester

"GATLING GUN" SHOCK TUBE being installed at Cornell Aeronautical Lab will be used for hypersonic testing of aircraft, missiles, and space vehicles. New facility will allow researchers to test vehicles at temperatures of 9000°F and speeds up to Mach 15 for periods as long as 15 seconds. The six-ton, $350,000 rotor is the largest precipitation-hardening stainless-steel forging ever made.

NEW DEPARTURES IN MINIATURE



HOW TO GIVE ON-THE-NOSE GUIDANCE TO MODERN "FISH"

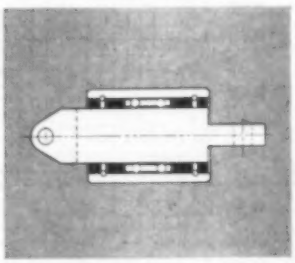
UNIQUE N/D LINEAR MOTION BEARING FREES GYRO CAGING ACTION

The bearing illustrated is an N/D linear motion precision instrument ball bearing. It was specially designed and built to help solve a critical problem in the guidance system of a high speed anti-submarine torpedo.

PROBLEM: Loss of accuracy in torpedo's guidance system due to hang-up of caging arm in gyro assembly.

SOLUTION: N/D Sales Engineer, in cooperation with manufacturer, found that *wear* of bushing on caging arm caused hang-up, delaying guidance activation. N/D Engineers set to work to design and build an instrument bearing that operates virtually friction-free. The result: Preservation of the guidance system's pin-point accuracy and reliability.

Should you require ball bearing design information, invite the local N/D Sales Engineer to participate in your early design discussions. He represents one of the industry's largest engineering staffs devoted exclusively to the design and development of miniature and instrument ball bearings. Or, write for new Miniature and Instrument Ball Bearing Catalog, Department L.S., New Departure, Division of General Motors Corporation, Bristol, Connecticut.

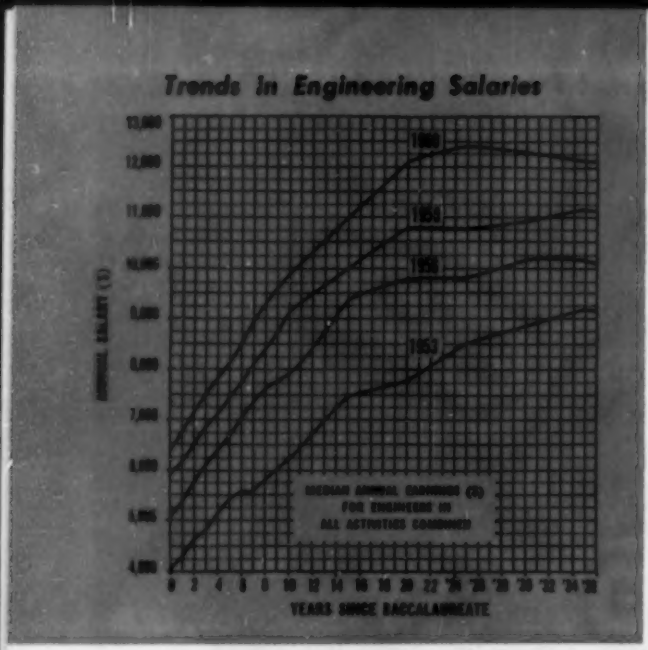


This special N/D linear motion instrument ball bearing increased guidance reliability of ASTOR torpedo weapon system developed by Westinghouse.

NEW DEPARTURE

MINIATURE AND INSTRUMENT BALL BEARINGS

Circle No. 6 on Subscriber Service Card



Engineers' Pay Continues to Climb

Engineering Manpower Commission finds that median salary is 5% more than in 1958, but raises drop after experience

by William Beller

ANNUAL EARNINGS of engineers rose to a median of $9600 last year, an increase of nearly five percent over 1958. Eight years ago, the median was only $6500.

For experienced men, engineering salaries in industry during 1960 were markedly higher than those in Federal government. Surprisingly, the median professional income of an engineer in education was within about $1000 of an engineer with the same experience working in industry.

These figures are part of a statistical survey of the income of engineers conducted by the Engineering Manpower Commission of the Engineers Joint Council. Founded in 1941 and based in New York City, the Council is an organization of many of the leading engineering societies, representing over a quarter of a million engineers.

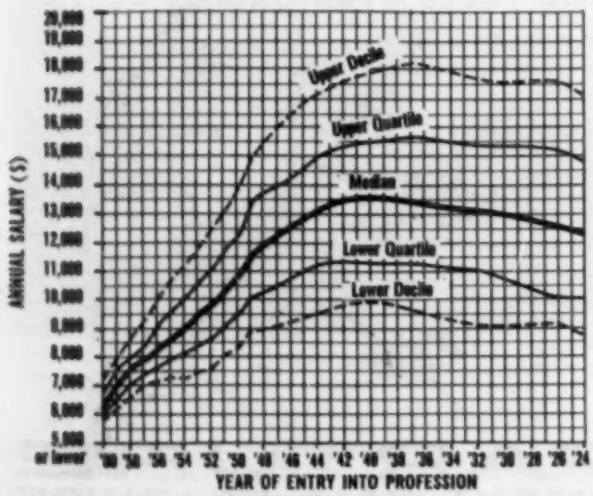
For gathering salary data, this survey was the largest sampling of engineers ever made in the United States. Working chiefly through engineering personnel offices—to avoid possibly biased reports—the Commission salary-checked 185,000 engineers. These included about one-fourth of all engineers employed in industry, and about one-sixth of those in government.

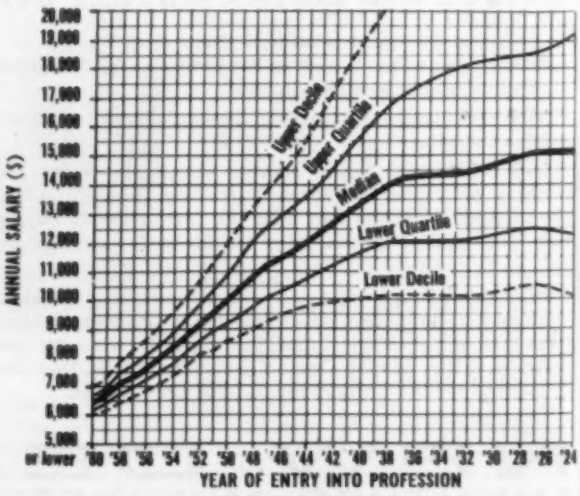
The Commission regretted that a growing number of Federal agencies were refusing to contribute salary data, the response dropping from 42 agencies in 1958 to only 25 in 1960. The Commission also noted "with disappointment" the continued unwillingness of companies in the automotive industry to participate in the survey.

In the seven-year period between 1953 and 1960, while the median years of experience of engineers hovered around 10, the median salary of engineers rose almost 50%. This figure may be compared with a 10% increase in the consumer price index and a 27% increase in the average weekly wages of production workers over the same time period.

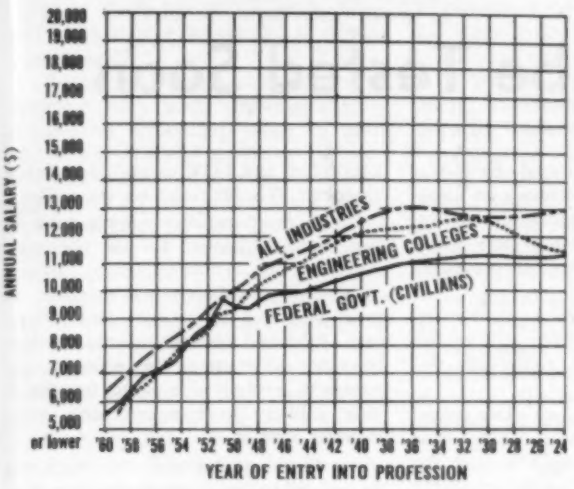
Although the starting salaries of engineers have been rising steadily and substantially—faster that the median salaries—the increases the engineers receive over their first 10 years have been leveling off at about $350 a year.

• **Diminishing returns**—Trends indicate that after an engineer has 10 years' experience, his yearly salary increments tend to become less and less; after 20 years' experience, the engineer with

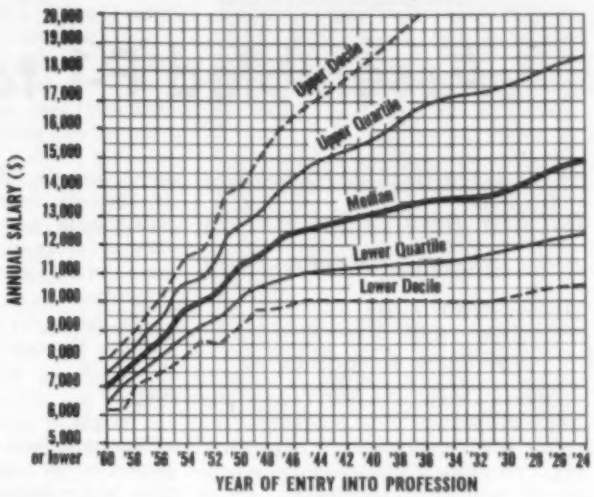




Median Engineering Salaries



Research & Development



a median salary pattern gets only small and sporadic raises.

In general, a couple of thousand dollars would more than cover the difference in median salaries paid engineers, no matter whom they work for. In their ceiling salaries is where the big differences are seen. For example, in industry the annual salaries of engineers in the upper decile during 1960 were all above $24,000. In education, the professional incomes of engineers in the upper decile were also high, reaching over $20,000 a year. On the other hand, government engineers in the upper decile were barely able to creep beyond the $14,000 mark.

For most engineers in industry, a $14,000 annual salary was the ceiling. In the field of aircraft and parts, the median engineer in 1960 reached his maximum salary of $13,500 after 20 years' experience, then his pay began slipping. In the other engineering fields, the median salary tended at least to remain constant after reaching a maximum.

• **Degree-conscious**—The statistics indicate that engineers with advanced degrees earn appreciably more than those without them. For instance, the difference between the average salary of an engineer with a doctorate and one with only a master's degree is about $2000. Similarly, the master's degree shows up about $1500 better than the bachelor's.

The top salary of the median engineer with a doctorate was $17,500 a year, which he got after 28 years' experience. The median engineer with a master's got a top of $15,000 after 32 years' experience and the median engineer with a bachelor's got a top of almost $13,000 after 24 years' experience. A similar relationship holds true for engineers in the upper decile.

In this study, the following definitions were used:

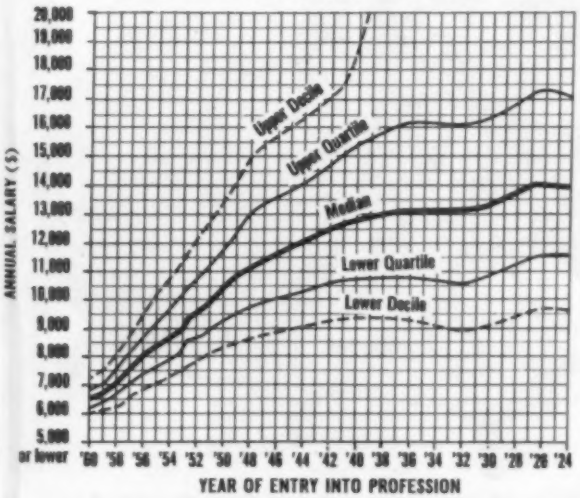
(1) Earnings—Base salary paid by employers including cost of living allowance, if any, and bonus if considered part of salary but not including payments for overtime work.

(2) Professional income—Total annual income from activities related exclusively to the practice of engineering, for the engineer in the field of engineering education.

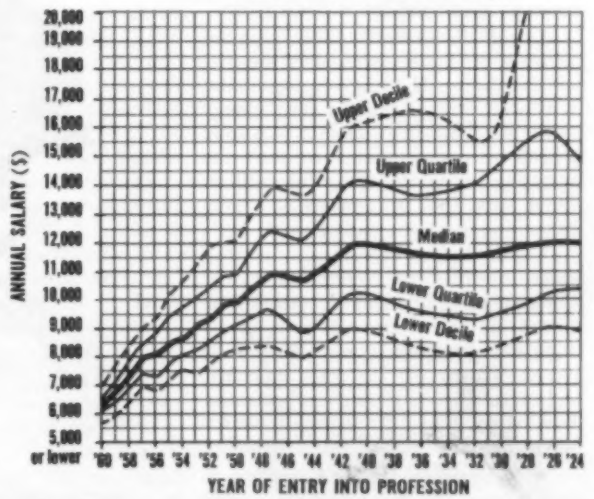
(3) Median—The point in any array of data above and below which half

(Continued on page 43)

Electrical Machinery and Electronics



Instrument Manufacturing



An M/R Exclusive

Assembled F-1 to be Tested Soon

Subassemblies to be joined for first time; emphasis on data collection, analysis will slash PFRT runs

by Frank G. McGuire

CANOGA PARK, CALIF.—Tests of the entire Rocketdyne F-1 liquid-propellant rocket engine assembly this month will begin proving out the design philosophy of the man-rated engine—for which there is still no vehicle. During the tests, to be conducted at Edwards Air Force Base, the injector, thrust chamber, turbopumps and other subassemblies will be combined for the first time. In the past, subassemblies were tested individually.

Initial tests will be carried out at thrust levels slightly over one million lbs. thrust, gradually building up to the maximum 1.5 million lbs. thrust level designed for the engine. Rocketdyne emphasizes the man-rated nature of the F-1's design, which is expected to require only about half the "several hundred" preliminary flight rating tests (PFRT) which were necessary for *Thor* IRBM engines. The F-1 will be ready for flight tests in early 1963.

Principal difference in design of the F-1 is the stress factor increase from the standard 1.2 to at least 1.5 times the maximum expected working pressure or surge. (The 1.5 design stress factor is equivalent to 1.2 times the quantity of 99.5% of the operating envelope plus surge.)

David E. Aldrich, F-1 program manager at Rocketdyne, says the F-1 and the *Saturn* H-1 engines are similar in concept except for the start energy source used. Whereas the H-1 uses solid propellant gas generator to start the operating sequence, the F-1 utilizes initial tank head to fire the gas generator and start the turbopumps.

Liquid oxygen valves open first, followed by fuel, in a pressure ladder sequence using interlocking valves. One failure in the system will shut everything else down. A hypergolic ignition system is used for the main chamber, and spark ignition for the gas generator. Triethylboron is sometimes used, but triethylaluminum is more nearly standard.

• **Reliability first**—According to Rocketdyne, the biggest problem with man-rating the reliability of the F-1 is its sheer size. Internal stresses on materials dictate a meticulous design review at every stage—a review much more formal than those in preceding programs.

In the words of Rocketdyne's Dr. Charles Davenport: "We all realize there will be a man riding on this thing."

Weight penalties for an extra pound of structural beef in the F-1 are not as severe as on other engines, and the extra beef is preferred for the reliability it provides. Nevertheless, there is no place for great generosity in the allocation of weight, even though the National Aeronautics and Space Administration encourages the beefed-up, reliable approach.

Reliability comes first . . . performance second.

In the sequencing of the engine, various functions must be performed or a shutdown will occur. The pressure ladder approach insures that proper sequencing is followed by the engine's fluid-handling system; ignition is used as a final veto power.

Dominick J. Sanchini, F-1 assistant program engineer, points out that ignition-detection wires must be burned through before valves can open to admit fuel and LOX to the combustion chamber. No ignition, no propellants.

In a multi-engined vehicle such as that often envisioned for the projected *Nova* booster, failure of ignition in one of several chambers doesn't appear to pose much of a danger, Rocketdyne says. *Atlas* and *Saturn* clustered boosters have not encountered this problem, the company says, and a large booster is also unlikely to run into any great troubles with it.

• **Data emphasized**—To back up its reliability requirement for the F-1, Rocketdyne is building a statistical test design unit for advance design of experiments, thus calling for "pre-thinking" of all phases of the system.

Digital data via the Rocketdyne Automatic processing of Integrated Data (RAPID) is simultaneously handled on an IBM 7090 computer. Much more data is obtained through serialized component analysis.

The immediate effect of the great emphasis on data collection and analysis will be the anticipated reduction in the number of runs required for PFRT. Another benefit will be the tightening of procedural control, tolerances and overall quality control.

Tolerances currently used in fabrication of the F-1 are on the machine-

ENGINEER INSPECTS full-scale mockup of the huge Rocketdyne F-1 engine.

tool level, rather than the aircraft level, and are hovering about the 0.003 in. to 0.004 in. mark for the thrust chamber, and much tighter on valves and similar components.

Reliability through simplification is achieved with such techniques as a direct-drive turbopump using no gearbox at all. The turbopump speed, incidentally, is 6000 rpm, with a fuel flow approximating 2% of the main engine flow—estimated at two tons of LOX and one ton of narrow-cut kerosene (RP-1) per second.

The 15,000-lb.-gross-weight engine has its turbopump mounted directly on the thrust chamber for simplicity and compactness. All other components are mounted on one of these two subsystems or on the plumbing between them.

In gimballing, the high-pressure ducting is not flexed. Instead, the entire engine is gimballed, using the fuel as a high-pressure hydraulic actuating medium.

• **Little wiring**—Only two components in the engine use electrical wiring or energy—the four-way solenoid valve and the spark igniter for gas-generator ignition. Fuel, oxidizer and gas-generator valves use fuel as their actuator hydraulic medium. To eliminate the turning movement of butterfly or ball valves, the fuel and LOX valves in the F-1 are the poppet type, which simplifies sealing problems and minimizes package size.

Duration of the tests to be conducted at Edwards will be shortened from expected operational levels due to a limitation on propellant capacity at the test facilities. Huge, high-pressure tanks of stainless steel with five-in.-thick walls can hold up to 20 seconds of propellant for the F-1. Control valves for these tanks weigh six tons.

Thrust chambers will be mounted in a position 30 degrees below horizontal, to eliminate the need for a flame deflector. Several engines can be tested on the same stand to check out clustering techniques, and a capability for testing clusters up to 12 million lbs. thrust is in reserve. Rocketdyne has done virtually no testing of the F-1 under a million lbs. thrust.

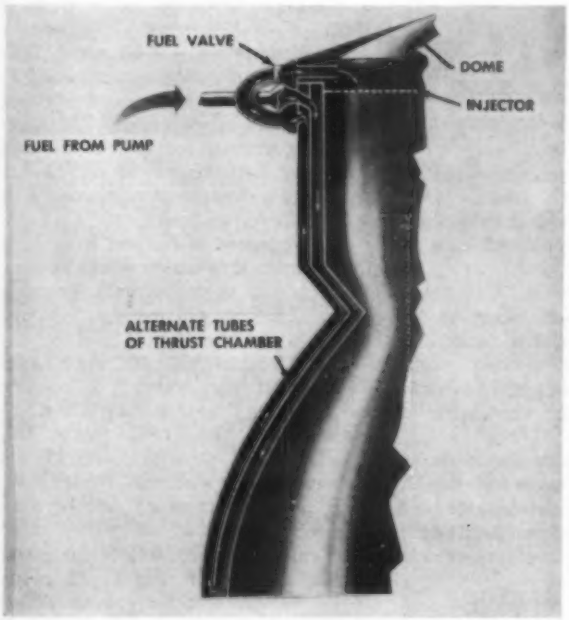
• **Three blocks**—Upon completion of its PFRT, the F-1 will have gone through three design blocks. The first is that based on purely theoretical calculations, the second will be a major cleanup of deficiencies found in the first block, and the third block will be a polished product ready for flight tests.

For the first block, Rocketdyne had the advantage of using existing hardware left over from an Air Force contract for a megapound-thrust rocket engine. This contract, going back to 1955, provided Rocketdyne with some injector hardware for conducting the first three firings in the F-1 program for NASA.

Rocketdyne's first rocket engine firing at one million lbs. thrust was carried out in early 1959, using Air Force hardware, and demonstrated stable combustion.

The F-1 is slated to undergo its preliminary flight rating tests in late 1962, completing the series in early 1963 with 18,000 seconds of development testing to its credit. First tests, beginning this month, will stress the start and shutdown sequences in short-duration runs. Then will follow checkout of performance, durability, reliability, and repeatability factors.

As an estimate of what a clustered F-1 vehicle could do, Rocketdyne assumes a typical application in a six-engine booster with 9,000,000-lbs. thrust. Such a booster would put 400,000 lbs. into a low earth orbit, possibly for space assembly of a large vehicle for interplanetary missions. Other payload capabilities would depend on upper staging, types of upper-stage engines, and similar variables. ⌗



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Will Russians go ahead?

Redstone Wins Okay for Mercury

Escape system and landing bag still face tests; shot of manned capsule may come late this month

AMERICA'S PROJECT *Mercury* —in an apparent losing race to launch the first man into space—has given a stamp of approval to the *Redstone* booster.

Two final spacecraft qualifications, the capsule escape system and a landing bag to reduce the effect of impact with the water, remain before a manned flight can be scheduled with *Mercury Redstone 3*.

Present indications are that it might be possible to launch a man by the last week of April. However, Russia may well have orbited a man by then. Presumably, Soviet authorities are going through an agonizing decision this week on whether their capsule is ready for manned flight with a record of three successes in five attempts.

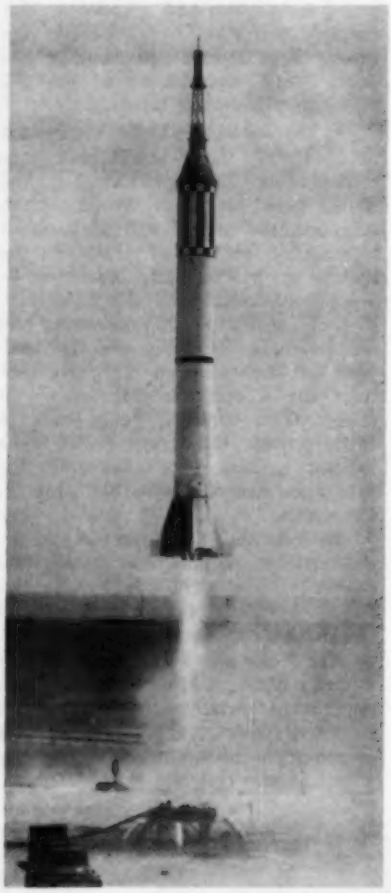
The U.S. *Mercury* program gave final approval to the *Redstone* after a March 24 flight in which it plunged into the Atlantic Ocean with a boilerplate capsule a half-mile from the target, 311 miles down the Atlantic Missile Range from Cape Canaveral.

The *Redstone* ballistic development flight carried the rocket to an altitude of 115 statute miles. Neither capsule separation nor recovery was planned. Maximum acceleration during the flight was 6½ g.

Final qualification work with the capsule landing bag is under way in a series of parachute drop tests in the Atlantic off the Virginia coast. An Air Force cargo plane has been dropping the recovered *MR-2* capsule from altitudes of 30,000 to 35,000 ft. off Hampton Roads. The tests, which began about two weeks ago, are expected to continue another week or so.

The landing bag, which broke off in impact with the sea on its first test with *MR-2* Jan. 31, worked properly on the *Little Joe 6* flight March 18. However, that flight did not provide a thorough qualification test for the bag because both the main and reserve parachutes opened at altitude, slowing descent much more than normal.

• **Little Joe premature**—Thorough analysis of telemetry data from the *Little Joe 6* flight at Wallops Island, Va., showed it fired prematurely instead of late, as reported last week (M/R, March 27, p. 61). A signal by ground command later accomplished capsule separation.



PROOF OF Redstone booster's fitness was this successful firing on March 24.

The *Little Joe* capsule was flown back to the McDonnell plant in St. Louis for fitting with new retro and escape packages for another flight aboard a new *Little Joe*. McDonnell is expected to return the capsule in a week or so.

Since the new *Little Joe* flight is likely to take place in a few weeks, NASA officials have decided to hold up the manned *Redstone* flight until after both *Little Joe* and completion of the drop tests.

Meanwhile, The Martin Co. announced it is obtaining the services of more than 30 companies to aid in its studies of Project *Apollo*, the NASA post-*Mercury* manned spacecraft, free of charge.

Martin, Convair and General Electric are conducting parallel six-month *Apollo* studies for NASA under six-month cost-sharing $250,000 contracts due for completion May 15. Martin listed these companies as among those from which it is obtaining services:

Propulsion — Aerojet-General, Bell Aerosystems, Grand Central Rocket, Marquardt, Pratt & Whitney, Rocketdyne, Thiokol and United Technology. Guidance — American Bosch Arma, Autonetics, Raytheon and Sperry Phoenix. Recovery — Cook Research, Goodyear Aircraft, Kaman Aircraft, Radioplane and Thiokol. Tracking & telemetry—AiResearch, Bendix, Electro-Mechanical Research, Epsco, RCA and Tele-Dynamics. Environmental control—AMF, Hamilton Standard, Hoffman Electronics, International Rectifier, Sundstrand Turbo, Thompson Ramo Wooldridge and Westinghouse. ¤

NASA Set to Ask Bids For Ion Engine Vehicle

MARSHALL SPACE Flight Center is expected to seek industry bids soon on a spacecraft to house the Hughes ion engine on its first flight test in October, 1962.

A *Scout* vehicle will launch the 200-lb. package containing one or two .002-lb.-thrust Hughes engines on a trajectory that will carry it above 250 nautical miles altitude for at least 50 min. Well over half the weight will be batteries and a dynamotor to provide 1 kw at 5-10 kv for an hour.

The purpose of the test is to prove that beam neutralization works in space and that the engine actually generates thrust. The test will measure whatever thrust is produced.

NASA added $321,000 to an earlier $490,000 Hughes contract to continue the work until more money is available from Fiscal Year 1962 funds. Ultimately, NASA plans to power ion and plasma engines with the *SNAP 8* nuclear powerplant, which will be available for flight test about 1965.

Centaur will probably be the launch vehicle for *SNAP 8*-powered orbital flights, which will carry both plasma and ion engines. Operational use may be possible by 1966 or 1967. ¤

industry

THIOKOL CHEMICAL Corporations earnings for FY 1960 fell 35% lower than 1959 earnings. Net sales dropped 10%, or $19 million.

The company said that in its missile activities, changing military requirements, combined with long delays in time between the submission of proposals and contract awards, affected volume and profits. "In addition," the annual reports said, "costs in excess of original estimate under certain costs-plus-fixed-fee type contracts were incurred."

A Nuclear Development Center was established by the company during the year and is teaming with several other firms in proposals pending to National Aeronautics and Space Administration and the Atomic Energy Commision.

Thiokol's sales for 1960 totaled $171.5 million, compared with $190.2 million. Net income last year was $3.56 million, off from $5.52 million the previous year.

UNION CARBIDE METALS CO. has established a Refractory Metals Dept. to produce and sell space-age metals such as columbium, tantalum, vanadium and tungsten. D. H. Barbour has been appointed general manager of the department. The company also has created a New Products Sales group, which will be under the direction of F. H. Buttner.

CHANCE VOUGHT CORP. has signed an agreement to acquire Harbor Boat Building Co. and Harco Engineering Co., both of Los Angeles. The company said the move was made to expand its antisubmarine warfare and marine engineering programs, and provide a salt water access to augment activities in oceanography, ship's instrumentation and other marine equipment.

DUPONT COMPANY started up its Belle, W. Va., plant, which will make methylamines and their derivatives, including DMAC, which it reduced in price by 30%. It also will produce DMA, a gas used in the manufacture of missile fuels.

ELECTROMAGNETIC TECHNOLOGY CORP., established at the Stanford Industrial Park, has been formed as a research, engineering and development organization. The company has technical interests in microwave antennas, components and systems, instrumentation, thermoelectric energy conversion, electromagnetic environmental control and application of microwave technology to various processing and control operations.

Vehicle Windows

(Continued from page 23)

ent upon several major factors, among them the environmental conditions and duty cycles of the specific application, the variations of material strength with temperature, the modulus of elasticity available at high temperatures, variations in the coefficient of thermal expansion, oxidization resistance and metallurgical stability at high temperatures.

The common sealing alloys such as Kovar, Therlo and Rodar are well suited to 1723 glass in the 0°-800°F range. But these alloys have such low yield strengths at temperatures that their use would have to be restricted to the function of an intermediate material, imparting a gradient expansion between the glazing and the high-expansion structural framing material.

Corning regards this gradient expansion design with interest, because of the position the Kovar type materials and the titanium family occupy between glazing and structural metallic expansion values in the 1000°-1600°F range. But the addition of an intermediate material in a framing design will require another sliding seal in the installation besides the one cushioning the glazing.

Molydenum alloys and some of the columbium family also exhibit low thermal expansion characteristics in the 0°-2400°F range. Corning believes that these alloys, combining high strength with low thermal expansion coefficients, will ultimately prove to be the ideal framing material for glazings. ⌗

Engineer Salaries

(Continued from page 39)

of the series is located, that is, the midpoint.

(4) Upper decile—The point in any array of data above which 0.1 of the series is located and below which 0.9 of the series is located.

(5) Engineers—Those holding a minimum of a bachelor of science degree in a recognized field of specialization in engineering.

(6) Year of entry into the profession—The year in which the engineering baccalaureate degree was awarded.

If the present trends are projected, the next biennial study probably will show the median engineer with no experience starting at between $6500 and $7000 a year. Ten years later he probably will be getting an annual salary somewhat more than $10,000. He can expect to get a maximum salary of about $14,000 after 20 years' experience. ⌗

Engineering Employment Opportunities in

EXPLOSIVE ORDNANCE

- ▲ Assistant Chief Engineer
- ▲ Principal Engineer
- ▲ Project Engineers

McCORMICK SELPH ASSOCIATES

Hollister Airport • Hollister, California

Send resume in confidence to Mr. H. C. Horsley, Personnel Mgr.

Requirements

General ordnance engineering; emphasis on propellants, ballistics, thermodynamics, hydraulics, mechanical design; responsible project engineering experience including preparation of proposals, costs, schedules and technical reports. Also seeking specialist with knowledge of exploding bridge-wire systems and devices, electro-explosive theory, and detonation wave theory.

HOLLISTER: convenient to San Francisco, Carmel, Monterey.

Circle No. 10 on Subscriber Service Card

contracts

NASA

$97,631—Beckman Instruments, Inc., Anaheim, Calif., from Marshall Space Flight Center, Huntsville, Ala., for design, development and fabrication of computing equipment for reduction of Doppler tracking data.

$96,411—Dynametrics Corp., Burlington, Mass., for design, development, fabrication and check-out of automatic calibration system for pressure transducers.

Wyle Laboratories, El Segundo, Calif., from Marshall Space Flight Center for R&D on evaluation of a high-accuracy mass flowmeter for use with liquid hydrogen. Amount not disclosed.

NAVY

$3,000,000—Huyck Systems Corp., Huntington, L.I., N.Y., for tactical antisubmarine warfare computer and display system.

$445,000—Electro-Tec Corp., South Hackensack, N.J., for slip ring assemblies for the *Tartar* missile program. Subcontract from The Raytheon Company.

$250,000—Olin Mathieson Chemical Corporation's Research Center, New Haven, Conn., for basic research studies in boron chemistry for ONR.

$171,000—Gladding, McBean & Co., Los Angeles, for further production of ceramic radomes for the *Sparrow III*. Subcontract from The Raytheon Co.

ARMY

$23,200,000—Western Electric Co., New York, and Douglas Aircraft, Charlotte, N.C., for production of *Nike-Hercules* missiles.

$4,029,019—Western Electric Co., Burlington, N.C., for production engineering services for the *Nike-Hercules* air defense missile system.

$584,574—The Raytheon Co., Waltham, Mass., for concurrent repair parts and retrofit kits for the *Hawk* missile system. Two contracts.

$300,000—Hughes Aircraft Co., Culver City, Calif., for continued development of an advanced guidance unit for the *Mauler* air defense system. Subcontract from Convair/Pomona Division of General Dynamics.

$476,545—The Raytheon Co., Waltham, Mass., for retrofit kits DA-19-020-ORD-5157.

$370,204—Radioplane Division of Northrop Corp., Van Nuys, Calif., for drone system AN/USD-1A. Two contracts.

$245,700—Microwave Associates, Inc., Burlington, Mass., for electron tube, Type 6229.

$208,874—Sperry Rand Corp., Salt Lake City, for publications, ground handling and test equipment for the *Sergeant* guided missile system. Four contracts.

$99,168—The Martin Co., Orlando, Fla., for repair parts and/or modification kits for *Lacrosse* systems.

AIR FORCE

$2,200,000—General Electric's Light Military Electronics Department, Utica, N.Y., for airborne transponder for use in the *Mistram* missile trajectory measurement system.

$935,000—The Marquardt Corp., Van Nuys, Calif., for continuing production of inlet controls systems, components, and spare parts for the *Hound Dog* missile. Subcontract from Space and Information Systems Division of North American Aviation, Inc.

$903,358—Sperry Rand Corp., Sperry Gyroscope Division, Great Neck, N.Y., for components of radar set AN/APN-59B, spare parts, ground support equipment and data.

$315,107—Philco Research Division, Philadelphia, for investigation of novel components as applied to a high-resolution radar antenna. Subcontract from Rome Air Development Center.

$285,000—Hill Electronics, Inc., Mechanicsburg, Pa., for development of a precision oscillator for the radio launch control system of the *Minuteman* missile. Subcontract from Electronics System Division of Sylvania Electric Products, Inc., Buffalo.

$280,000—Electro-Tec Corp., South Hackensack, N.J., for components used in AN/FPS-26 height-finding radar antenna. Subcontract from the Electronics and Ordnance Division of Avco Corp.

$196,374—Kearfott Division, General Precision, Inc., Little Falls, N.J., follow-on from Wright Air Development Division for gas-bearing gyros.

$192,000—Defense Electronics Products Division of RCA, Moorestown, N.J., for nonpersonal technical services for on-site scheduled overhaul and emergency technical assistance and supply support of two each AN/FPS-16 instrumentation radars of the Atlantic Missile Range.

$160,000—Sylvania's Reconnaissance Systems Laboratory, Mountain View, Calif., for development of anti-intrusion equipment; specialized alarm system designed to protect restricted areas from unauthorized entry. From Rome Air Materiel Area, Griffis AFB.

$112,000—The Electronics Division of Chance Vought Corp., Dallas, for production of actuator housings for the *Titan* ICBM. Subcontract from The Martin Co., Denver.

$94,000—Electro Nuclear Systems Corp., Minneapolis, for development of advanced data processing techniques to be used in a classified military porgram.

$94,000—The Unitec Corp., Baltimore, for emergency depot level reconditioning of eight each rigid radomes.

$91,972—Lockheed's Missile and Space Division, Sunnyvale, Calif., to design and fabricate spectrometers for the measurement of high-energy protons in the Van Allen Belt.

$90,738—General Electric's Missile and Space Vehicle Department, Philadelphia, for regenerative fuel cell for space power use and technical personnel for checking its operation under weightless conditions during planned jet aircraft flights.

$85,000—Northeastern University, Boston, for theoretical and experimental research on Statistical Communication Theory.

$55,018—Lockheed Aircraft Corp., Burbank, Calif., for investigation of effect of communications and navigation satellites upon EMS concept and design.

$30,000—Grand Central Rocket Co., Redlands, Calif., for design criteria, specifications and consultation relative to conversion of portions of the plant to a facility capable of manufacturing propellants and loading, assemblying, packing and testing propellant rocket motors, components and accessories.

$26,857—California Computer Products, Downey, for control logic and system design for vehicle system.

$26,083—Dynatronics, Inc., Orlando, Fla., for airborne telemetry test and calibration systems.

Space Technology Laboratories, Inc., Los Angeles, for detailed systems engineering and technical direction for those *Atlas* and *Titan* ICBM boosters to be used in support of the *Nike-Zeus* program. Amount not disclosed.

reviews

METALS HANDBOOK, 8th Edition, Vol. 1—PROPERTIES AND SELECTION OF METALS. American Society for Metals, Novelty, Ohio. 1300 pp., $30.

The ASM Metals Handbook eighth edition is devoted exclusively to the selection and properties of metals. It is the first of a projected series of volumes which will, when completed, cover all branches of metals engineering and metalworking.

A new section provides coverage of stainless steels (both cast and wrought), including the more recently developed precipitation-hardening alloys.

Separate sections are devoted to aluminum, magnesium, iron-base super-strength alloys, nickel-base and cobalt-base alloys, and titanium and titanium alloys. Included in a section on carbon and low-alloy steels, are a number of special articles dealing with selection for maximum yield strength, hardenability, fatigue resistance, notch toughness, wear resistance, and resistance to corrosion.

The book has a completely cross-referenced 64-page index.

OXIDATION BEHAVIOR AND PROTECTIVE COATINGS FOR COLUMBIUM AND COLUMBIUM-BASE ALLOYS, W. D. Klopp. Order PB 151 080 from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. 97 pp., $2.25.

The report summarizes and discusses the information available to Dec. 1959 on the oxidation behavior of columbium and columbium-base alloys.

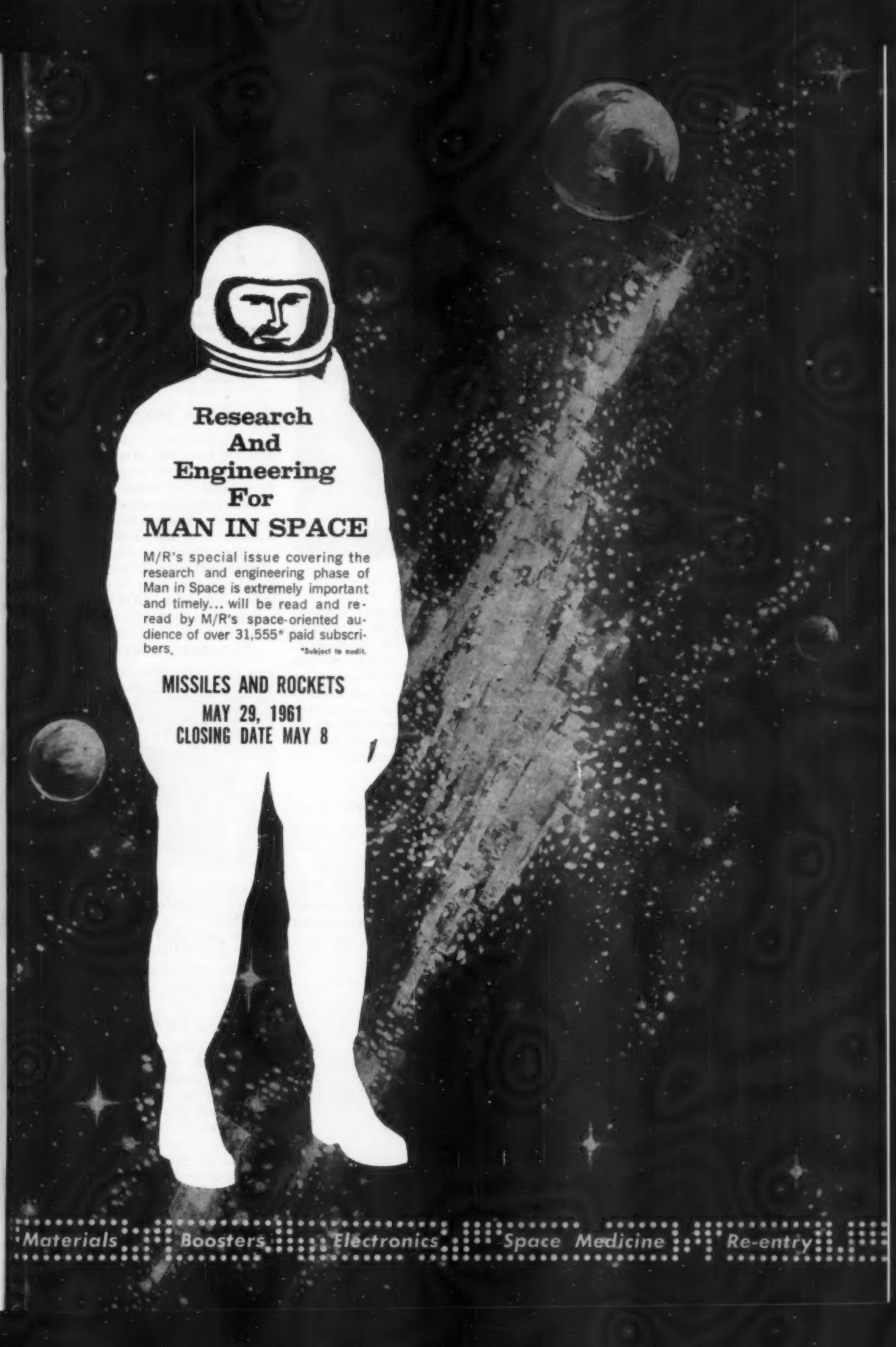
The data are presented in three sections. Under oxidation behavior of columbium are discussed the columbium-oxygen system, and the reaction of columbium with oxygen, air, or nitrogen.

In the section devoted to alloys, oxidation behavior data are given for 20 binary columbium alloys and seven ternary and more complex columbium alloys. The section on protective coatings for columbium includes a discussion of coating requirements, types of coatings and methods of application. Also included in this section is a summary of test results on the efficacy of various types of coatings, giving evaluations of electroplated, vapor-and-pack-deposited, clad, sprayed, and liquid-phase diffused coatings, as well as an evaluation of undefined coating processes.

PROPERTIES OF REFRACTORY MATERIALS: COLLECTED DATA AND REFERENCES, W. G. Bradshaw and C. O. Matthews, Lockheed Aircraft for U.S. Govt. Order PB 171 101 from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C., 110 pp., $2.50.

A comprehensive survey of the properties of refractory materials with melting points above 2500°F was made to assist in the selection of materials which show promise for use in high-temperature missile and nuclear applications.

The physical, mechanical, and chemical characteristic of these materials at elevated temperatures are presented in tabular form.


Research
And
Engineering
For
MAN IN SPACE
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MISSILES AND ROCKETS
MAY 29, 1961
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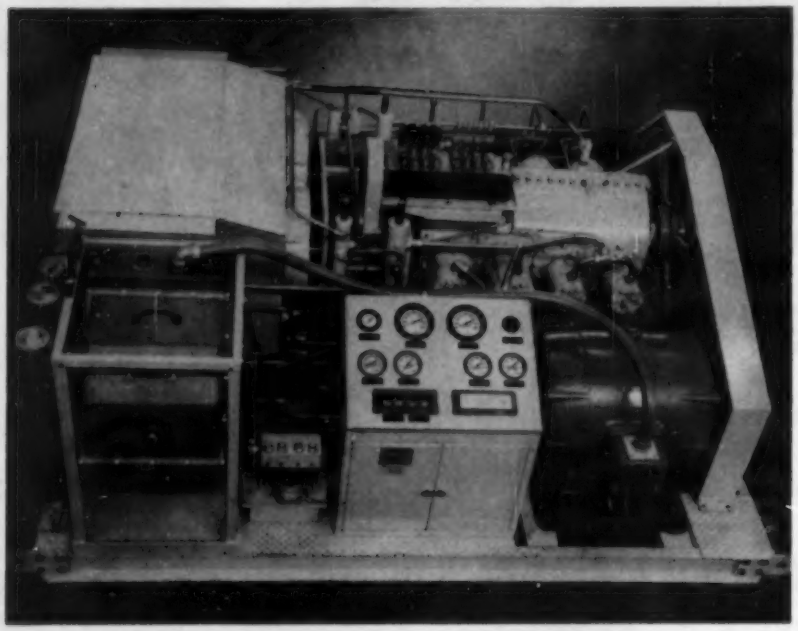
Space Medicine
Re-entry



High-Capacity Compression System

A central compression system specially designed to meet the increasing need for relatively high-capacity, short-time or continuous delivery of maximum-purity air, helium, nitrogen or other gases is available from Cardair, Division of Marmon-Herrington Co., Inc.

The systems, known as DPB-CCS, guarantee supply of gas at discharge pressure of 3500 to 12,000 psi continuous, with less than 1 ppm oil content and dewpoint of −100°F. Capacity is 150 scfm at 128 psig intake, utilizing a 4-stage, 8 cylinder compressor as standard. The complete system includes dehydration and oil removal equipment and control panel. Maintenance is said to be minimal and simple, with nationwide service facilities available.

Circle No. 225 on Subscriber Service Card

Compact ADC

An analog-to-digital converter with a conversion rate of 0.5 microseconds and measuring only 6½ x 3½ x 6¼ in., is available from the General Data Corp.

The solid-state ADC, General Data Model 101, requires only a single decision per conversion, instead of the usual successive approximation technique.

Input voltage range of the unit is 10 volts at an impedance of 250 ohms. An optional input impedance of 100,000 ohms is also available. Accuracy is ±.5%, ±½ least significant digit.

Circle No. 226 on Subscriber Service Card

Satellite Recorder

A miniature magnetic tape recorder/reproducer for satellite and missile application, capable of operating on 1/20 of the power previously considered practical, has been developed by the Datalab Division of Consolidated Electrodynamics Corp.

Power consumption is rated considerably less than one watt, and size is expected to approximate 100^3 in. when the design configuration is finalized. It has an estimated life of at least 4000 hours, operates at a reproduce-to-record speed ratio of 18:1 (ratios up to 100:1 are feasible), and weighs less than six lbs.

Circle No. 227 on Subscriber Service Card

Printed Circuit Relay

A high-reliability microminiature relay designed especially for printed-circuit applications is available from Control Dynamics Corp.

The relay—named the Centipede—has a height of only 0.44 in., making it ideal for military and commercial applications where vertical space is limited. The relay's eight terminals and four mounting pins fit on 0.200-in. centers for standard printed circuit grid mountings.

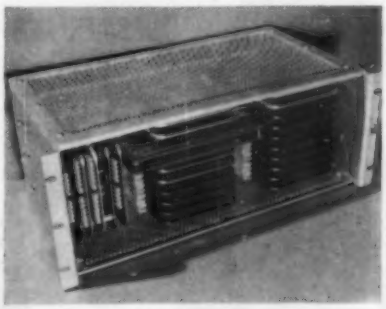
Circle No. 228 on Subscriber Service Card

Instruction Memories

High-speed BIAX magnetic core instruction memories in several standard sizes are available from Aeronutronic Division of Ford Motor Co.

The memories operate at one megacycle, with an access time of 0.4 microsecond, using non-destructive readout BIAX memory elements. Two standard sizes are presently available—128 words and 512 words, with 24 bits per word. Other sizes up to 1024 words and 36 bits per word can be built on a fixed-price basis to customer specifications.

No rewrite circuitry is needed for



the non-destructive BIAX memory, and loading equipment, also available from Aeronutronic, is detachable. Loading can be performed at speeds up to 200 kc if desired, but the standard input is from punched paper tape.

Circle No. 229 on Subscriber Service Card

Metallic Static Face-Seal

Haskel Engineering & Supply Co. is marketing a line of metallic static face-seals designed and manufactured specifically to meet the high pressure and extreme temperature requirements of systems in missiles and high-performance aircraft.

The HS Series Seal can be utilized to provide zero leakage at a wide range of temperatures from −450° to 2000°F and pressures to 20,000 psi.

The seals are lapped to provide flat-

ness and smoothness of the sealing faces. A flat surface with a finish of 32 RMS or better is adequate to provide a mating surface. The seals incorporate an integral spacer which avoids the problem of controlling groove depth closely. Installation is accomplished by merely indexing the seal to one mating surface and bringing the opposing surface against the seal.

Circle No. 230 on Subscriber Service Card

Magnetic Drum Check-out

FMA, Inc. has developed test equipment for recording timing tracks and providing general check-out of a magnetic drum system.

Known as the Model MD-100 Magnetic Drum Check-Out System, it offers clock recording, clock smoothing, origin and word track recording and test pattern recording.

A clock track may be recorded circumferentially around the drum with a pre-selected number of bits, up to 16883. Closure on this timing track may be made better than 50 millimicroseconds. The system is capable of recording in either the non-return-to-zero (NRZ) or in the Manchester method.

Circle No. 231 on Subscriber Service Card

Metal Film Mylar

Filmohm Corp. is showing a thin and completely flexible microwave absorbing material. The resistance material is a thin film of pure metals, approximately 50 millionths of an inch thick, uniformly deposited on the surface of the Mylar. Any value between 25 and 400 ohms/square can be supplied, tolerance is ±10%. Standard values are 50, 100, 150, 200, 300 and 377 ohms/square. Silver contact areas can be provided for DC contact. These must be applied before deposition of the resistance film. DC contact cannot be made to the film in any other way. Nominal resistivity in ohms/square, thickness, and date of manufacture is stamped on the back of each sheet.

Circle No. 232 on Subscriber Service Card

Pulse Generators

A line of pulse generating equipment featuring high repetition rates and fast rise and fall times is available from Texas Instruments Inc.

The line includes two clock pulse generators and a programed pulse generator. Extremely fast rise and fall time pulses are achieved through the unique design of the equipment's solid-state circuitry.

The Clock Pulse Generators include a 3-25 mc unit and a 25-100 mc unit with appropriate overlap to provide continuous pulse sources from 3-100 mc. Provision has been made in the

design to allow for external drive input to provide repetition rates below 3 mc and to permit the operation of several Clock Pulse Generators controlled by a master source.

Circle No. 233 on Subscriber Service Card

Semiconductor Test Equipment

Molecular Electronics, Inc., is introducing four types of semiconductor-device test equipment.

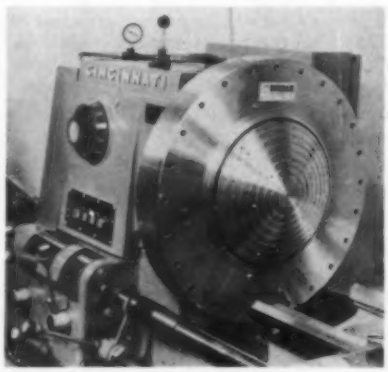
The semiconductor-device test equipment includes 1) an in-circuit test set, 2) a general-purpose tester, 3) an alpha-cutoff test set and 4) a gain-bandwidth tester.

A general-purpose test set also will be displayed, which can measure AC and DC parameters for both diodes and transistors. Leakage currents down to 1.5 microamps (full scale) also can be detected with the new unit.

Circle No. 234 on Subscriber Service Card

Vacuum Chucking System

Dunham Tool Co., Inc. is marketing a missile vacuum-checking system for holding missile and aircraft components such as ceramic nose cones and stainless parts up to 100 in. in diameter. Activated by a vacuum pump with hold-down pressure of 12 psi,



chuck develops over 33,000 lbs. of distortion-free, hold-down pressure on a 60 in. diameter part. An automatic safety device is incorporated to prevent loss of vacuum in case of power failure.

Special designs permit boring I.D., facing and turning O.D. concentric within 0.001 in. on parts up to 100 in. in diameter. Also, forgings and sand castings can be chucked with equal facility.

Circle No. 235 on Subscriber Service Card

Missile Diagnostician

An automatic electronic analyzer that will predict the operational readiness of an intercontinental ballistic missile, or any other complex weapon system, is available from Hughes Aircraft Co.

The machine is called D-PAT, short for "drum-programed automatic tester." Using a digital computer with test-program procedures stores on a magnetic memory drum, D-PAT detects and isolates malfunctions in any system down to the smallest replaceable unit or assembly.

With its memory drum whirring at 2300 revolutions a minute, D-PAT electronically clicks through a system checklist, confirming its own measurements with known values stored on the drum, and automatically starts exploring to investigate a suspected trouble spot.

Circle No. 236 on Subscriber Service Card

Telemetry Decommutator

An "off-the-shelf" PCM telemetry decommutation unit is available from Electro-Mechanical Research, Inc. The decommutation unit is expected to make digital telemetry a practical reality for all telemetry users.

The versatility of the system permits its use as a universal ground station, since it accepts any time-multiplex signal, whether PAM, PDM or PCM, and provides both analog and digital outputs.

Designated the Model 185 Digital Decommutation Unit, the equipment can be set up to accept these signals by setting a single knob. The standard decommutator accepts a wide variety of word and frame formats, including all IRIG-specified formats, at bit rates up to 80 kc. Between 10 and 128 channels or words per frame can be handled. PCM inputs can be parallel or serial binary in RZ, NRZ, or NRZI. Words may be any length from 5 to 16 bits, and word sync can be any 2 bits at any location within the word. Frame sync may be the first or last word of the frame, as selected, and any frame sync code pattern set up by the operator may be recognized.

Circle No. 237 on Subscriber Service Card

names in the news

CENTER

KING

CLARK

Dr. Mervin J. Kelly: Research engineer and electronics scientist, appointed a special consultant by **James E. Webb,** Administrator of the National Aeronautics and Space Administration. He will investigate a number of areas where space science and technology may have practical applications at an early date and will advise the Administrator on matters of related space sciences. He was with Bell Telephone Laboratories for 41 years, retiring as chairman of the board two years ago. Since then, he has been serving as adviser to the president of International Business Machines Corporation.

H. Herbert Jackson: Named manager of the *Nimbus* weather satellite control system for General Electric's Missile and Space Vehicle Department, Philadelphia. Prior to joining GE, Jackson was an aeronautical research scientist at the NACA Pilotless Aircraft Research Division, Langley Field, Va.

Dr. Ercole E. Motta: Appointed director of chemical sciences, Dynamic Science Corporation, San Marino, Calif. He was formerly deputy director of the special products department of the Atomics International Division of North American Aviation.

William Lawrence and **Howard L. Gates:** Appointed general manager and manager of operations, respectively, of General Dynamics/Electronics' Military Products Division, San Diego.

Dr. Claude L. Clark: Metallurgical engineer, Timken Roller Bearing Co., Detroit, will receive the Albert Sauveur Achievement Award of American Society for Metals. The award is being made in recognition of Dr. Clark's outstanding contributions toward advancing knowledge of metalworking technology.

Dr. Jean I. F. King: Former manager of Physics Operations at General Electric's Missile and Space Vehicle Department, Philadelphia, appointed director of Plasma Physics Laboratory of Geophysics Corporation of America, Bedford, Mass.

J. M. Cummings: Named manager of Space Engines, a new subdivision of Research and Engineering at Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif. Previously he was manager of Rocketdyne's Small Engines subdivision in Liquid Propulsion Engineering.

Maurice Center: Joins the Astrionics Division of Fairchild Engine and Airplane Corporation, Wyandanch, Long Island, N. Y., as general manager. Center was formerly program director for the "Missile Master" Air Defense Coordination System of The Martin Company.

Dr. Charles F. Gell: Chief of life sciences for the Astronautics Division of Chance Vought Corporation, appointed clinical professor of physiology at the University of Texas' Southwestern Medical School in Dallas, to further the joint efforts of both organizations.

Alfred H. Canada: Former technical consultant on infrared and optical techniques for the Advanced Research Projects Agency, named manager of engineering for Raytheon Company's Santa Barbara Operations.

Dr. James H. Gardner: Elected a vice president of National Research Corporation, Cambridge, Mass., and will continue to serve as general manager of the Metals Divisions.

Frank H. Gardner and **Martin Schletter:** Veteran development engineers of Tenney Engineering, Inc., Union, N. J., named managers of the newly-organized Aerospace Division and the Environmental Division, respectively.

Peter Churm: Named vice president of The Fluorocarbon Company, Anaheim, Calif. Churm will continue as general manager of the Teflon and Kel-F processor and fabricator.

Harley D. Peter: Formerly of Vitro Electronics, joins Communication Electronics, Inc., Bethesda, Md., as a senior electronic engineer.

Armand A. Lakner: Named aeronautical and space scientist, Systems Analysis Office of the National Aeronautics and Space Administration, Washington, D. C. Lakner formerly was with Lockheed Aircraft Corporation, Marietta, Ga.

letters

Report on Guidance

To the Editor:

I have just finished reading M/R's 4th Annual Electronics Issue (Feb. 27) and want to compliment you on your handling of the subject. In particular, I feel that your round-up on guidance as covered in the "Market Outlook" story was unusually newsworthy and comprehensive.

Mike Cannon
Librascope Div.
General Precision, Inc.
Glendale, Calif.

To the Editor:

I have delayed commenting on your Electronics Issue until I was able to peruse the magazine at some length. This was accomplished with difficulty, because the copies were snatched from me almost instantaneously by various and sundry sales, contracts, planning and engineering people.

Reader interest in the guidance and control equipment issue has been tremendous, I understand. I'm one of the crowd. It was very well done and highly informative.

Robert S. Knapp
Sperry Gyroscope Co.
Great Neck, N. Y.

To the Editor:

(The issue) is a great comprehensive coverage of guidance and the treatment was impartial and generous.

We ordered reprints for distribution at the IRE Convention in New York Coliseum.

Wallace C. Baker
American Bosch Arma Corp.
Hempstead, N. Y.

Man-Machine Discipline

To the Editor:

Permit me to express my appreciation for a fine job of technical reporting by Charles D. LaFond in his article, "How Can Pilot Best Control Ship's Attitude?" (M/R, March 6, p. 36).

His point that "Only the surface has been scratched in this quest for critical knowledge" is well taken. Lear, through its Advance Engineering Division, is deeply entrenched in the overall, complex study of how best to design the machine to obtain optimum man-machine performance. A scientific method of approach to this optimization has been sorely needed in past systems; the success of future system complexes may well be dependent upon the successful establishment of such a scientific discipline.

C. E. Barlow
Mgr., Advance Engineering Div.
Lear, Inc.
Grand Rapids, Mich.

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SPACE MEDICINE?

—when and where—

APRIL

International Symposium on Electromagnetics and Fluid Dynamics of Gaseous Plasma, Polytechnic Institute of Brooklyn, Institute of the Aerospace Sciences, AFOSR, ONR, U.S. Army Signal Corps., Auditorium of the Engineering Societies Bldg., New York City, April 4-6.

American Rocket Society, Lifting Reentry Vehicles: Structures, Materials and Design, Palm Springs, Calif., April 4-6.

Society of Automotive Engineers, 1961 National Aeronautic Meeting, New York City, April 4-7.

American Society for Testing Materials, Symposium on Materials and Electron Device Processing, Benjamin Franklin Hotel, Philadelphia, April 5-7.

Institute of the Environmental Sciences, Annual Meeting and Equipment Exposition, Sheraton Park Hotel, Washington, D. C., April 5-7.

American Institute of Chemical Engineers, Management Engineering Conference, sponsored with AIEE, ASME, IRE, AIME, Statler Hilton Hotel, New York City, April 6-7.

Six Lectures on Synthesis of Intelligent Behavior, sponsored by Institute of Radio Engineers, and Society for Industrial and Applied Mathematics (SIAM) University of Pennsylvania, Philadelphia, beginning weekly April 10 to May 15.

ASME Maintenance and Plant Engineering Conference, Bancroft Hotel, Worcester, April 10-11.

The Combustion Institute, Western States Section, Aeronutronic Division of Ford Motor Co., Newport Beach, Calif., April 10-11.

Cincinnati Sections of the Society for Applied Spectroscopy and Instrument Society of America, Symposium, Cincinnati Gardens, Cincinnati, April 11-12.

Air Force Office of Scientic Research, Conference on Ultrapurification of Semiconductor Materials, New England Mutual Hall, Boston, April 11-13.

Symposium on Information and Decision Processes, Purdue Univ., Lafayette, Ind., April 12-13.

Cincinnati Section IRE, and Southern Ohio Section of American Rocket Society, 15th Annual Spring Technical Conference, Electronic Data Processing, Hotel Alms, Cincinnati, April 12-13.

Institute of the Aerospace Sciences, Army Aviation Meeting (classified), Washington, D. C., April 13-14.

Seventh Military Operations Research Symposium, ONR, at Boeing Airplane Co., Seattle, April 17-19.

CLASSIFIED

Army Navy Country Club

Is offering for sale 475 acres located on Route 28 at Chantilly, Virginia in the immediate vicinity of Dulles International Airport. Write or call Richard E. Daley, General Manager, Army Navy Country Club, Arlington 4, Virginia.

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editorial . . .

Odd Caution on the New Frontier

CHANGES IN THE FISCAL '62 missile/space budgets outlined by President Kennedy are certain to run into strong opposition in Congress and elsewhere.

His amendments to the Eisenhower budget call for increased military spending of $650 million with new obligational authority of nearly $2 billion. The budget increase for the National Aeronautics and Space Administration totals $85 million with new obligational authority of $125 million.

This hefty financial shot in the arm is welcomed by the industry. But it seems to have been achieved with a hodgepodge of compromise certain to arouse the wrath of influential members of Congress and the industry.

An outstanding example of this is the decision to once again cut back the B-70 program—but not all the way. This seems like a sure way to anger both B-70 supporters and those B-70 critics who feel the program should be dropped.

The President has said, in effect, "We don't really think much of the B-70 but we're going to buy a few, anyway." It's an approach that smacks a little too much of political expediency. The program should either be killed or implemented in a sensible fashion. There's a lack of courage in the present position.

Subcontracting on the B-70 program has been extensive. Hundreds of firms are involved. How anyone can expect them to carry out sound financial planning in a program that has become a political football escapes us.

Additional furor can be expected over the *Nike-Zeus* decision. The Army has gathered strong support on the Hill for its plan to push *Zeus* into production as soon as possible. The Administration has decided to mark time until after the Pacific tests.

And where is the money in the NASA budget to exploit the potential of the breakthrough in solids? The decision to accelerate the *Saturn* program and to step up funding of the F-1 engine is commendable. But aren't we willing to risk anything on the possibility of a really significant return on a strongly-backed solid booster program? Or will we wait until the Russians demonstrate what can be done?

Certainly there will be no strong opposition to the increase in spending in the *Polaris* program. Nor can there be informed opposition to most of the cutbacks in the revised budget. The implication that *Polaris* is replacing the mobile *Minuteman* will draw no arguments from anyone who has seen what war can do to a railroad. This and cancellation of the two *Titan II* squadrons have been offset to a certain extent by approval of three additional *Minuteman* fixed squadrons.

The death blow to the *Eagle-Missileer* program will be a severe jolt to the companies involved. But the Administration should find it relatively simple to defend its refusal to fund a new subsonic aircraft and a Mach 3 missile for defense of aircraft carriers.

The nuclear aircraft program has limped along for too many years, spending too many dollars; it's doubtful that anyone will shed too many tears over it.

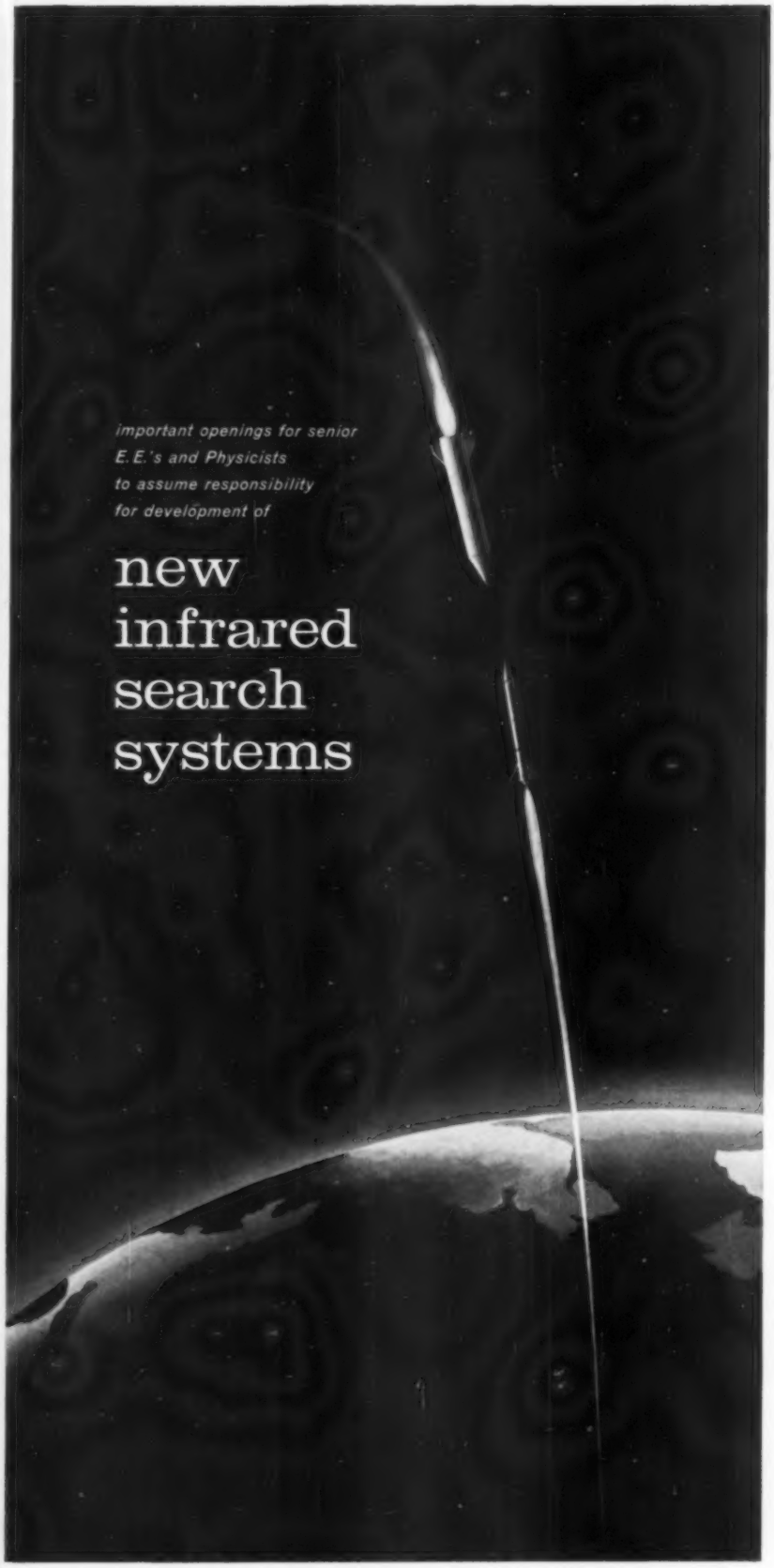
OVERALL, IT IS NOT the cutbacks in the revised budget which we deplore. It is the failure to take the limited financial risk of exploiting the promising new projects and programs.

The Eisenhower-Kennedy budget as it stands is a patchwork document resulting from the necessity of a too-hasty review by the Kennedy Administration. This certainly is one of the penalties of the administrative changeover required by our democratic form of government.

But we find the cautious wait-and-see attitude of these New Frontiersmen a little strange. We always thought a willingness to take a courageous gamble was necessary to build a new frontier.

We look forward to the Kennedy Fiscal '63 budget in the hope it will reflect the sensible but bolder approach of a longer period in office.

William J. Coughlin



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3. **Air-To-Air Detection Search Sets**
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5. **Infrared Range Measurement**
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8. **Optical Systems Design**

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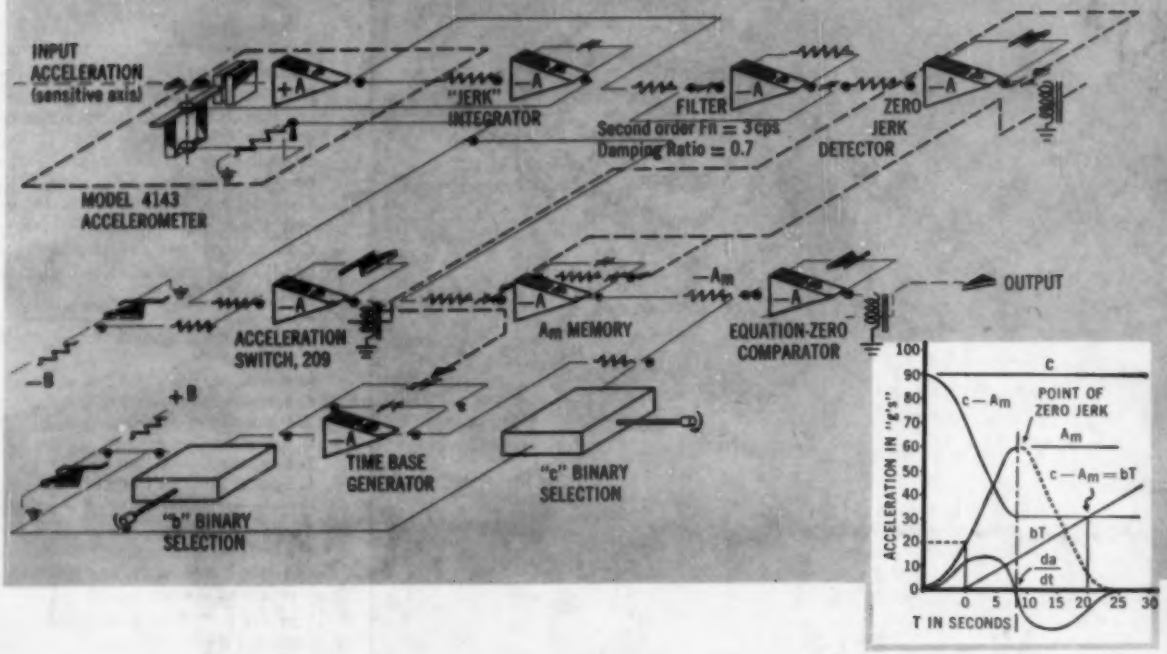
1961

Functional Diagram of Donner Accelerometer Timer Switch. Basically an airborne computer designed to solve a specific equation, this Donner device consists of a force balance accelerometer, whose output feeds to a jerkmeter for determination of peak acceleration (Jerk (da/dt) is the first derivative of acceleration). From the jerkmeter the signal passes through a filter and to a zero jerk detector which closes a switch at the peak acceleration. Other units in the computer are a peak acceleration memory, a 20 g acceleration switch which starts a time base generator and prevents the zero jerk detector from operating before a correct solution is possible, "b" and "c" selection binary units allow 64 values of "b" and "c" to be selected within the operating range, and an equation zero comparator which algebraically sums the output of the maximum acceleration memory circuit, time base multiplied by "b" and "c" circuit to close the relay output when $bT = c - A_m$. The curve below illustrates the equation and the fact that peak acceleration occurs at zero jerk.



How to Solve a Flight Equation

New Donner Airborne Analog Computer solves equation $bT=c-A_m$

where b = predetermined constant, T = time in seconds, c = predetermined constant, and A_m = peak acceleration achieved.

Causing a missile event to occur at just the right time and place in space is one of the critical problems faced by the control engineer. The programming device must be light, accurate, strong and, above all, reliable in severe environments.

When Donner engineers were confronted with this problem, they came up with a fixed purpose airborne analog computer known more specifically as an acceleration summing switch. The summing switch is a "thinking" device which responds to a particular environmental stimulus. Thinking for the vehicle, the switch measures time, multiplies it by a preset constant, equates the product to the memorized peak acceleration subtracted from a constant and when the sum reaches a predetermined value, actuates a relay. Such a point occurs during decreasing acceleration and is dependent on the magnitude of peak acceleration.

In solving this problem, Donner engineers combined their experience with computer techniques and servo force balance accelerometers. The device illustrated is all solid state.

Acceleration Summing Switch. This remarkable small computer is approximately 4" high and 2½" across. The two knobs on the top are used to set in "b" and "c" constants of the equation.

COMPLETE TECHNICAL INFORMATION AVAILABLE
If you would like more information about this interesting application of computer and transducer techniques, our Mr. Stephen P. Cuff has prepared a technical discussion which he will be happy to send along. Please write Mr. Cuff at Donner Scientific.

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